JOURNAL

OF THE

A. I. E. E.

~~American Institute of Electrical Engineers~~

1929

PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West 39th Street, New York

PUBLICATION COMMITTEE
W. S. Gorsuch, *Chairman*, H. P. Charlesworth, F. L. Hutchinson, Donald McNicol, E. B. Meyer

George R. Metcalfe, *Editor*

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Publications of the A. I. E. E.—The chief publications of the Institute are the JOURNAL, QUARTERLY TRANSACTIONS, A. I. E. E. STANDARDS, and the YEAR-BOOK.

The JOURNAL, a monthly publication which every member receives, contains two sections, one devoted to technical papers, and the other to current activities of the Institute and other related subjects of engineering interest. The technical section consists largely of rather complete abridgments of the papers presented at conventions and meetings of the Institute. These are brief enough to enable the reader to keep posted in the various fields of engineering which the papers cover; and complete copies of any paper are sent gratis to the reader who wishes to specialize on any subject. The second section of the JOURNAL is designed to keep members acquainted with the activities of the Institute and with the news of the engineering world in general.

The QUARTERLY TRANSACTIONS contain the papers and discussions at Institute meetings and are the only publications in which they are printed in full. These volumes are designed principally for reference books, and are furnished to members at a very nominal cost. These volumes practically constitute the history of the art of electrical engineering, as they contain papers covering every major electrical development.

The A. I. E. E. STANDARDS which were formerly published in a single book have so increased in volume that they are now divided into more than thirty individual sections and the number is constantly growing. This arrangement gives greater latitude in publishing revisions of any sections promptly, and convenient binders are furnished for filing all the individual sections under one cover. An index for the complete set is also available. The standards are supplied to members at a very small cost.

The YEAR-BOOK is published annually and contains an alphabetical and a geographical list of members corrected to January first each year. It also includes a section giving general information about the Institute, the Constitution, By-laws, Code of Principles of Professional Conduct and the Annual Report of the Board of Directors. The Year-Book is sent free to members on request.

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The societies with which these reciprocal arrangements have been established and are still in effect are: Institution of Electrical Engineers (Great Britain), Societe Francaise des Electriciens (France), Association Suisse des Electriciens (Switzerland), Associazione Elettrotecnica Italiana (Italy), Koninklijk Instituut van Ingenieurs (Holland), Verband Deutscher Elektrotechniker E. V. (Germany), Denki Gakkwai (Japan), Norsk Elektroteknisk Forening (Norway), Elektrotechnický Svaz Ceskoslovensky (Czechoslovakia), and The Institution of Engineers, Australia (Australia).

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The Summer Conventions are designed to be less strenuous than the Winter Convention and they are usually held in various parts of the country at summer resorts, where the technical activities and the recreation features can be about evenly balanced. Several years ago the Board of Directors, recognizing the benefits to be derived by members from personal contacts and social intercourse, ruled that the technical sessions be confined to the mornings, leaving the balance of each day free for social and entertainment purposes, and in recent years the Summer Convention programs have been formulated upon this ruling. The same high grade is maintained in all convention papers, wherever presented, but the number of papers placed on the Summer Convention programs is reduced in proportion to the smaller number of technical sessions scheduled. An important feature of each Summer Convention is the presentation of the Technical Committee reports, each of which covers a distinct phase of electrical engineering and brings the advances and improvements in the art thoroughly down to date.

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The Pacific Coast Conventions as their name implies are always held in the Pacific Coast States or British Columbia, and were inaugurated for the benefit of Western members who by reason of their location could not conveniently attend the conventions held in the eastern part of the country. The engineering problems encountered in the West have also been different to some extent from these in the East owing to the very long-distance high-voltage transmission systems which are characteristic of the Pacific Coast region. The programs of these conventions cover all phases of electrical engineering but accentuate those features which are of peculiar interest to western engineers. Social and entertainment features are always included, as well as inspection trips of special interest to visitors from a distance.

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PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

33 West 39th Street, New York

PUBLICATION COMMITTEE

W. S. GORSUCH, *Chairman*, H. P. CHARLESWORTH, F. L. HUTCHINSON, DONALD MCNICOL, E. B. MEYER

GEORGE R. METCALFE, *Editor*

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The Winter Conventions are usually the outstanding technical meetings of each year and are held in the eastern section of the country, generally in New York City. The programs consist chiefly of technical sessions which occupy practically all the available time of a five-day meeting, except one day which is set aside for inspection trips to engineering works of interest in the neighborhood of the convention city. Aside from the entertainment provided for ladies in attendance, the only social function is a dinner-dance held on one evening during the convention. The Winter Conventions have been described as the "working conventions" of the Institute because the social and entertainment features are almost entirely subordinated to the consideration of technical papers.

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Library Service.—The Engineering Societies Library is the joint property of the four national societies of Civil, Mining, Mechanical, and Electrical Engineers and comprises one of the most complete technical libraries in existence. Arrangements have been made to place the resources of the library at the disposal of Institute members, wherever located. Books are rented for limited periods, bibliographies prepared on request, copies and translations of articles furnished, etc., at charges which merely cover the cost of the service. The Director of the library will gladly give any information requested as to the scope and cost of any desired service. The library is open from 9 a. m. to 10 p. m. every day except holidays and during July and August, when it closes at 5 p. m.

JOURNAL OF THE A. I. E E

DEVOTED TO THE ADVANCEMENT OF THE THEORY AND PRACTISE OF ELECTRICAL ENGINEERING AND THE ALLIED ARTS AND SCIENCES

The Institute is not responsible for the statements and opinions given in the papers and discussions published herein. These are the views of individuals to whom they are credited and are not binding on the membership as a whole.

Vol. XLVIII | APRIL, 1929 | Number 4

ARE we torch bearers for the engineers of the morrow?

What can and should the profession, working through the Institute, do to furnish the most effective guidance to the engineering novitiate?

This is a major problem of our Committee on Education.

The members of this Committee, representing educators and executives of electrical industries, are giving this subject earnest attention under the able leadership of Chairman Edward Bennett of the University of Wisconsin. They have agreed that the most promising line of first action would be an investigation of means of stimulating the extension of professional education *after graduation.*

The personnel of the Committee gives assurance of worth while accomplishment. Whatever plan or suggestion matures from their deliberations it is certain that the *active aid of practising engineers* will be required to carry it to success. Professor Bennett stated this well last summer in accepting the chairmanship:

> The primary function of the Committee is to bring the thought of the group of practising engineers to bear upon some of the problems of engineering education.

Practising engineers appreciate that it is beyond the scope of colleges to turn out full fledged engineers. The quality of the engineering done by our successors will in a large measure be determined by what the present generation of practitioners does to guide the graduates.

Dr. W. E. Wickenden, Director of Investigation, S. P. E. E., and recently elected President of the Case School of Applied Science, and who has probably given this general subject more complete study than any other one man, in an article sometime ago stated the case thus:

> Engineering education can be bettered in details by the efforts of the colleges acting alone, but it can be made adequate to its task in American life only when it becomes a part of far-seeing plans for the development of our profession and our industries.

The practising engineer must take the lead in developing such plans.

Engineers have thus far done little to foster the growth of group consciousness and professional pride. They have apparently failed to note the beneficial effect on the legal and the medical professions of the attitude taken by lawyers and doctors. In a recent letter Prof. William H. Timbie of Massachusetts Institute of Technology comments on this as follows:

> It seems to me we may well take a leaf out of the book of the medical profession. On the day the young student arrives in the medical college he is called "Doctor" by everybody. When he goes back home at vacation time the local physicians seem to know about him and make it a point to become acquainted with him * * * * Other physicians make it a point to invite him to witness particularly interesting operating cases at the hospital. In fact, everything is done to make him feel that he is one of the profession and to increase his interest and knowledge in the various aspects of his work.
>
> * * * * Surely the older engineers can in a large measure show the same interest in the young engineer graduate that the medical profession does in its younger members.

The educators have their own organization for the discussion of curriculum and related problems in the S. P. E. E. The part that the practitioners should play is common to all branches of engineering. The subject seems to be sufficiently important to warrant the appointment of a semi-permanent committee on education with joint representation from *all* of the national engineering societies.

Meanwhile there are countless ways in which practising electrical engineers can aid through our Sections and Branches.

Chairman Bennett has written an article suggesting some of these ways. This will be found on page 310 of this Journal and its careful reading is commended to all leaders in Section activities.

It rests with you, fellow members, to determine the quality of engineering in the years to come.

R. F. Schuchardt

President.

Some Leaders of the A. I. E. E.

Charles Waterman Stone, Consulting Engineer for the General Electric Company, a Manager of the Institute 1908-1911, and one of its Vice-Presidents 1911-1913, was born in Providence, Rhode Island, Dec. 24, 1874. He attended the public schools in Providence and the West, and later, the University of Kansas for three and a half years. In 1894 he joined the Franklin Electric Company, of Kansas City, but two years later he returned to the East to become machinist for the W. S. Hill Electric Company, of New Bedford, Massachusetts. Where he was shortly advanced to engineer in charge. In 1899 he was chosen superintendent of construction for the Hancock Equipment Company, of Boston, of which he remained a member until he joined the General Electric Company later in that same year. His advancement was steady; starting in the Drafting Department, he was soon made assistant engineer of the Lighting Department; then engineer in charge of the Consulting Engineering Department, manager of the Lighting Department, and finally, manager of the Central Station Department, leading to his ultimate appointment as consulting engineer, his present capacity with the company. He is also consulting engineer for the RCA Photophone Company, Inc., devoting his time wholly to engineering subjects.

While with the W. S. Hill Electric Company, Mr. Stone did much valuable work in the design and construction of switchboards. From 1902 to 1906 he was designing and building power stations and substations, investigating the varying conditions which enter into this situation—working always for improvement in this vitally important branch of electrical engineering. At the same time, he has contributed generously to technical literature with representative papers before the National Electric Light Association, the Association of Edison Illuminating Companies and other professional bodies, and with frequent discussion of other papers, before the Institute and various conventions of the engineering groups. He became an Associate of the Institute in 1903 and in 1912 was transferred to the grade of Fellow, a grade he himself helped to create for the Institute Members, working with a special committee of the Institute to formulate Institute regulations governing this grade.

He is a member of the American Society of Mechanical Engineers, the Society for the Promotion of Engineering Education, the National Electric Light Association, the Society of Engineers of Eastern New York, the Illuminating Engineers, and the Franklin Institute.

While Mr. Stone has never actually assumed the role of teacher, he has lectured frequently before the Engineers School of Washington, D. C., at Columbia University and to other society and college engineering groups. His social contacts have also been broad as a member of the Mohawk Club, the Mohawk Golf Club, the Edison, Schenectady Curling, the Bankers Club of New York, the Lotos Club, the Engineers Club and the Electrical Manufacturers Club.

Beside his work as one of its Managers, and as a Vice-President, Mr. Stone has served the Institute as chairman of various convention committees, on the Code Committee, the Finance Committee, and in many other channels. His opinion has been valued and his endeavor earnest and successful in behalf of the engineering profession.

Reactions Between Insulators

The reactions between insulators built up into a string and the irregular voltage gradient along the assembly are well known, but the influence of the distance apart of the units has only recently attracted attention, as the increase of extra high pressures apparently demands an inordinate increase in the number of insulators to secure the same degree of safety.

A study of the influence of the separation of the insulators in a string was recently published by Niethammer and Nitsche, but the practical results obtained by G. Viel, mentioned in the *Revue Générale de l'Electricité*, are of particular interest. Insulators of the Hewlett pattern 280 mm. dia. and of the ball and socket Continental pattern 290 mm. dia. were subjected to test in a laboratory at Delle where 750 kv. were available, giving, among others, the following results:

String	Details	Flash-over pressure in kv. Dry	Wet
A	7 standard insulators	430	130
B	9 standard insulators	530	185
C	7 standard insulators with 5 cm. increased separation	520	218

showing that by elongating string "A" of 7 insulators by six spaces of 5 cm. between insulators to form string "C" the flash over pressure was increased in the dry test, 20 per cent., and in the wet test, 70 per cent., whereas, by increasing the number of insulators by 28 per cent and forming string "B" the [illegible] pressures were only increased 22 and 42 per c[illegible] was taken to secure accurate results by re[illegible] tests, and it is believed that the errors cannot exceed 5 per cent, which, considering the class of [illegible] tested, may be considered satisfactory.

Sound practise when increasing pressure [illegible] for instance from 120 to 150 kv., would seem to be the remodeling of the strings instead of adding insulators, especially as this increases the total length by only 3 cm. with but slight additional outlay. The remodeling of the strings in the manner indicated reduces the potential gradient across the first insulators on a string, and, as it is stated to affect equally both of the standard patterns tested, will no doubt influence the design of high tension insulators and lines.—*World Power.*

Abridgment of

Oscillographs for Recording Transient Phenomena

BY W. A. MARRISON[1]

Associate, A. I. E. E.

Synopsis.—Oscillographs which automatically record amplitude, wave form, frequency, duration, and the time of any electrical disturbances for which they are adapted as developed for recording transient phenomena are described. Two instruments are described for recording very short or very long transients; they may be used in combination. At power frequencies, satisfactory records may be made on films or sensitized paper with a two-watt lamp. The instruments and their performance are illustrated by photographs and oscillograms.

* * * * *

OSCILLOGRAPHS are described which were developed primarily for recording transient phenomena of which the time of occurrence is neither known nor subject to control. The apparatus described was designed primarily for recording transient inductive disturbances in communication lines from neighboring power circuits. For this two somewhat different types of oscillograph were developed. One makes records of short duration having uniform resolution throughout, the other makes long continuous records and may be arranged to record a disturbance of any reasonable duration. The former instrument records on a sheet of film rotating in its plane, and will be called a "polar oscillograph," while the latter records on long strips, such as motion picture film, and will be called a "continuous-film oscillograph."*

FEATURES COMMON TO BOTH OSCILLOGRAPHS

Since both of these oscillographs were designed for recording the same sort of phenomena and for operating under similar conditions, they have a number of features in common. The light source is a concentrated filament flashlight lamp placed close to a pinhole aperture. Because of the small size of the bulb which permits the filament to be brought very near the aperture, no condensing lens is used. The vibrator is of the moving-iron balanced-armature type similar to a driving element frequently used in loud speakers. With this type of oscillator it is possible to employ a mirror half an inch in diameter, and still retain a satisfactory frequency range and sensitivity. With such a mirror, it is practicable to use a lamp requiring only about two watts. Each oscillograph is equipped with a camera for photographing a clock on the oscillogram to indicate the exact time of occurrence of any disturbance recorded. A schematic diagram of the optical system of the recorder and of the camera, as used in the polar oscillograph, is shown in Fig. 1. A high-speed "line relay" is used with both oscillographs for operating certain automatic devices.

MAIN FEATURES OF POLAR OSCILLOGRAPH

A polar oscillograph is shown in Fig. 2 with the cover removed to show the optical system. The rotating member is separated from the remainder of the oscillograph by a circular light trap which permits free rotation while shielding the film from external light. The circular light trap used is illustrated in Fig. 3. With this arrangement, films may be exposed for days at a time under ordinary light conditions without appreciable fogging.

The chief value of this oscillograph lies in its ability

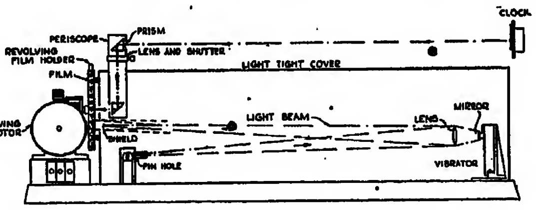

FIG. 1—ESSENTIAL ELEMENTS OF POLAR OSCILLOGRAPHS

to record with good resolution from the very beginning of a transient. To accomplish this, the lamp is lit continuously and a narrow shield is placed in the light path of just sufficient width to prevent light from reaching the film when the vibrator is at rest. In this way fogging is prevented during the time when no current is flowing in the vibrator but a record is made of any disturbance large enough to move the spot off the shield. This causes a narrow clear space to be left where a zero line is usually obtained. The shield may be removed from the light path when it is desired to record a zero line.

MAIN FEATURES OF CONTINUOUS-FILM OSCILLOGRAPH

The continuous-film oscillograph is shown in Fig. 4. It differs from the polar oscillograph mainly in the form in which records are obtained. The instrument shown makes records on motion picture film or sensitized paper of the same width which is advanced by means of a motion picture sprocket driven through gears and a

1. Engineer Bell Telephone Laboratories, Inc., New York, N. Y.

*This instrument is also known as the "Movie oscillograph."

Presented at the Regional Meeting of Middle Eastern District, No. 2, Cincinnati, Ohio, March 20-22, 1929. Complete copies upon request.

magnetic clutch from a variable speed shunt motor. The motor and associated gears are left running during the time a transient may be expected, and, when a disturbance occurs, a quick acting magnetic clutch engages the film driving shaft with the motor and the line relay lights the lamp. The whole recording mechanism may be put in operation within 0.02 second,

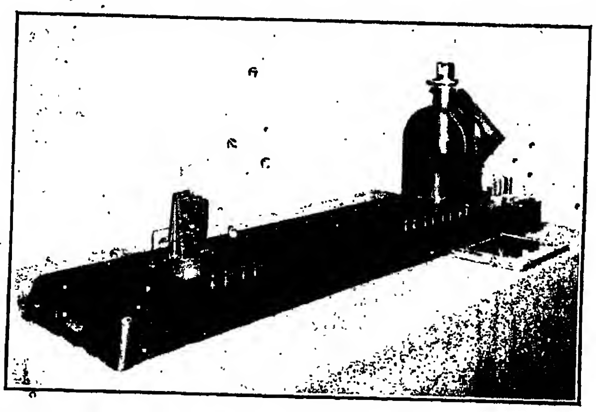

FIG. 2—POLAR OSCILLOGRAPH, SHOWING FILM ROTOR, PERISCOPE, LAMP HOUSING, AND VIBRATOR

thus insuring a good record of any but a very short transient.

With a voltage higher than normal and by the use of the circuit shown in Fig. 5, it is possible to light the

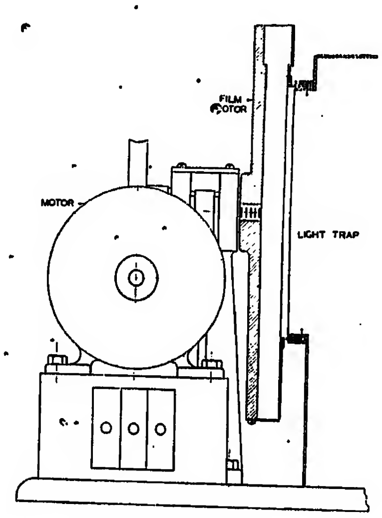

FIG. 3—SCALE DRAWING OF ROTATING LIGHT TRAP

lamp to full brilliancy within 0.01 of a second. When the lamp circuit is closed the condenser is charged suddenly to the applied voltage, the charging current passing through the filament. The resistance shunting the condenser has such a value that normal current flows through the lamp in the steady state.

The magnetic clutch, while designed to operate quickly, accelerates the sprocket and film without shock. When current flows in the annual coil, (see Fig. 6), a steel diaphram on the driven member is drawn against the circular electromagnet, traction being obtained at the outer edge of the diaphram. Due to the small clearance, and due to the small moment of inertia of the driven member, it is rapidly accelerated to maximum speed.

OPERATION

There are many ways in which the oscillographs described may be used. In one arrangement, two polar oscillographs and one continuous-film oscillograph have been used together for studying transients likely to occur at any time during long continuous periods.

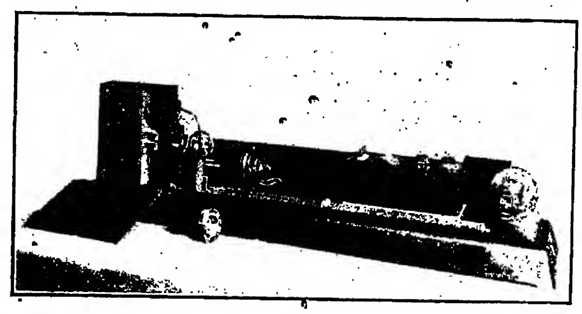

FIG. 4—CONTINUOUS-FILM OSCILLOGRAPH WITH COVERS REMOVED

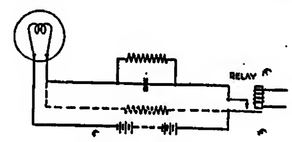

FIG. 5—CIRCUIT FOR LIGHTING LAMP QUICKLY

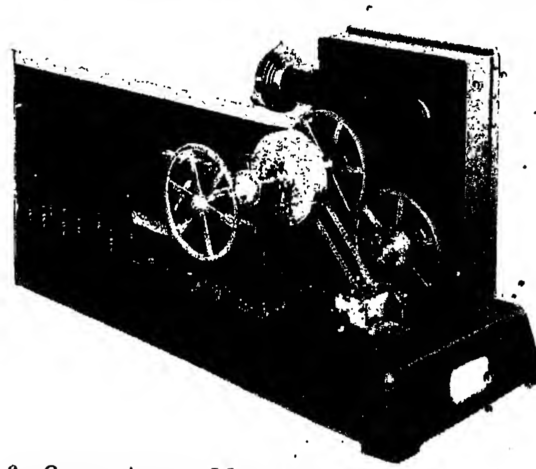

FIG. 6—QUICK ACTING MAGNETIC CLUTCH ON CONTINUOUS-FILM OSCILLOGRAPH

The arrangement is shown diagrammatically in Fig. 7. One of two polar oscillographs is connected in the circuit being investigated so that it is in condition to record the first part of any transient. A high-speed line relay associated with it is arranged to put the sequence switch in motion, which takes care of a number of operations consisting chiefly of starting the continuous-film oscillograph, substituting the spare polar oscillograph for the first after a short time interval and operating the camera shutters at the proper times.

The polar oscillograph obtains a record of the first part of the transient, while the continuous-film oscillograph obtains a record of the complete transient with the exception of the first few cycles. The record of a transient obtained with the two oscillographs used together is shown in Fig. 8. The polar oscillograph

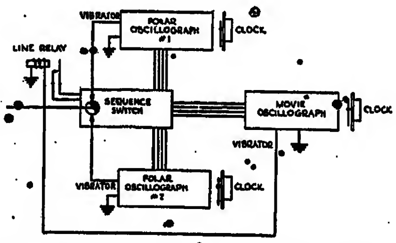

FIG. 7—ARRANGEMENT OF OSCILLOGRAPHS FOR RECORDING ANY TRANSIENT IN A LINE

Two polar oscillographs and one continuous-film with control equipment and clocks are arranged so that a transient of any duration occurring at any time will be recorded with a record of the time of occurrence.

began recording immediately, while the other began about five cycles later and continued 25 or 30 cycles beyond the end of the polar record showing the manner in which the transient ended.

With the continuous film type of oscillograph, a large number of records can be made at one loading. Because of this, it is possible, with the use of an automatic sequence switch, to make the oscillograph entirely

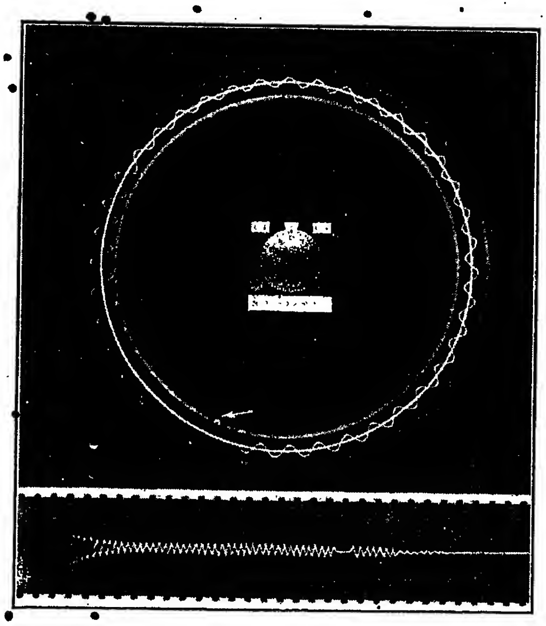

FIG. 8—SAMPLE OF RECORDS MADE BY POLAR AND CONTINUOUS-FILM OSCILLOGRAPHS USED TOGETHER

automatic in operation, causing it to record all of the transients in a circuit as they occur. Such an oscillograph may be left permanently connected into a circuit in which transients are expected, and at the end of any period the film that has been advanced into the "exposed" magazine will have records of the magnitude, frequency, and wave form of the disturbances and of the time of occurrence of each.

A modification of the continuous-film oscillograph is shown in Fig. 9 adapted especially for sampling a wave at regular short intervals instead of making a continuous record or merely a record of unusual disturbances. A rotating mirror sweeps the light beam along the oscillograph film past an aperture *A* so that the effective

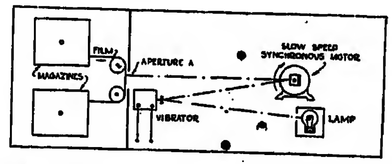

FIG. 9—SCHEMATIC DRAWING OF SAMPLING OSCILLOGRAPH

This oscillograph records one wave out of a number at regular intervals, say one cycle in sixty, with considerable resolution in order to record slow variations in wave form.

film speed during exposures is many times the actual film speed, and permits of exposure during only a small part of the total time. If the distance of the rotating mirror from the film is 8.5 in., one cycle of the wave recorded will be spread over approximately one inch of film. If a rotating mirror with a single facet is used, and if the aperture is just one inch wide, the actual film speed should be one inch in two seconds and every one hundred and twentieth wave will be recorded. The

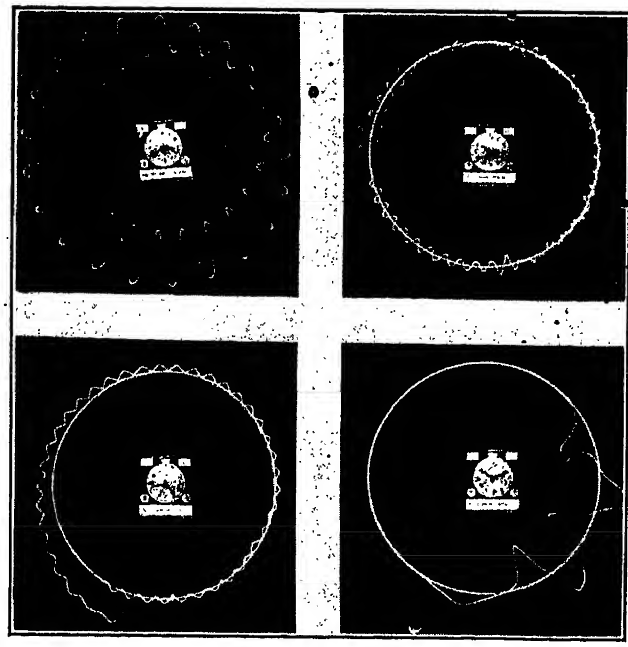

FIG. 10—SAMPLES OF POLAR OSCILLOGRAMS

advantage of this recording method is that good records of slow changes may be obtained without using a large amount of film.

Another method of sampling which gives a somewhat different kind of information may be used with a continuous-film oscillograph with the usual optical system. The film is advanced very slowly and at

intervals the speed is increased by an amount sufficient to show the actual wave form.

Performance

The limitations of an oscillograph lie mostly in the vibrator and, to a smaller degree, in the optical system. The frequency characteristic of the vibrator up to 800 cycles is quite uniform, permitting records of distur-

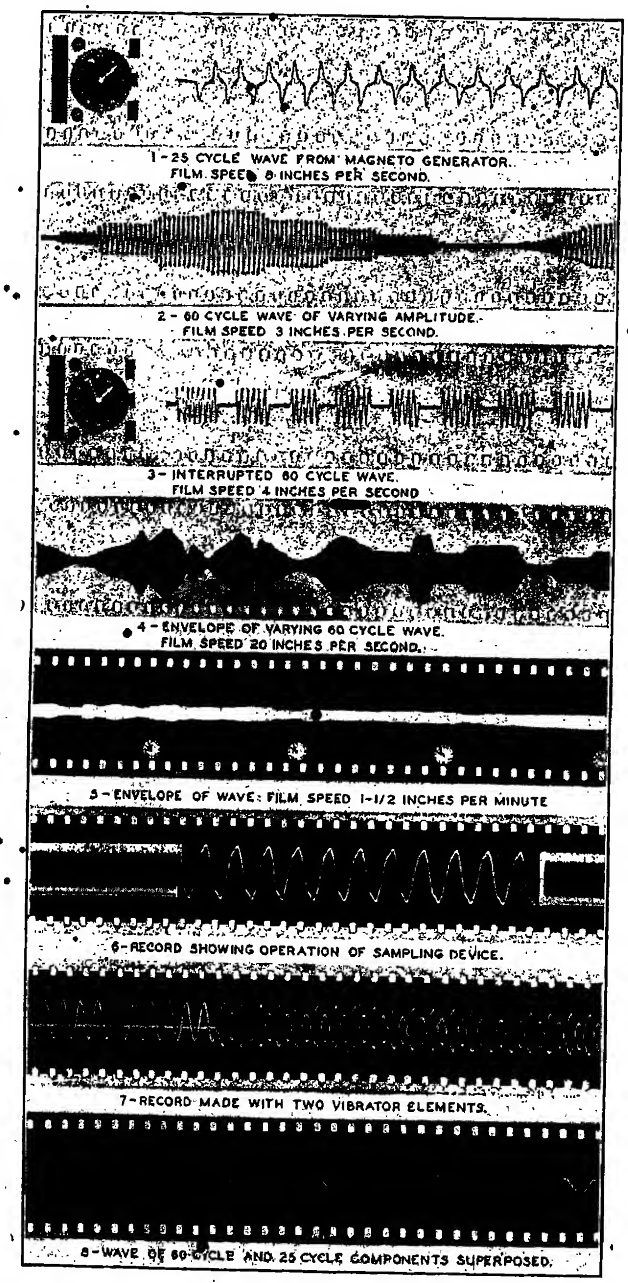

Fig. 11—Samples of Continuous-Film Oscillograms

bances having components in this range to be made with little distortion. This range includes the first 13 harmonics of 60 cycles and the first 32 harmonics of 25 cycles.

The vibrator may be wound to have any impedance in a wide range. If wound to have a high impedance, it is especially suited for recording voltage waves; and if wound to have low impedance, it is better suited for recording current waves. The sensitivity varies approximately as the square root of the impedance of the winding.

As noted previously the oscillographs described are intended for recording in a comparatively low frequency range. In the range given there has been no difficulty in obtaining good records with a two candle power flashlight lamp. This, of course, is due to the large size of the mirror on the vibrator.

A number of field applications of oscillographs of both types have been made with satisfactory results. In some cases where cooperative studies were being made, the oscillographs have been used for recording transient neutral currents in power systems as well as to record voltages induced in telephone circuits by power system transients. Experience with the oscillographs in these field installations has suggested a few improvements of a mechanical nature and certain rearrangements of parts to increase the convenience of operation. These changes are now being embodied in a new design. It is hoped that it will be possible in a later paper to describe these features and to give the results of field experience more fully than can be done at this time.

Abridgment of
SHORT-CIRCUIT TESTING ON ALABAMA POWER COMPANY SYSTEM
Its Procedure and Effects on Operation

By H. J. Scholz* and C. B. Hawkins†
Associate, A. I. E. E. Associate, A. I. E. E.

This paper sets forth the reasons for making short-circuit tests upon the system of the Alabama Power Company and describes the methods of testing. The results of the early tests clearly demonstrated the necessity for making such tests and the need for adequate facilities to gather data essential to a full knowledge of the limitations of electrical equipment under actual operating conditions. A description of the modern test equipment installed in the last two years, and the method of procedure in making tests are given. A discussion of the results obtained brings out the point that the expenditures for complete testing facilities have been fully justified and have resulted in the installation of better equipment, improved protection, and a higher grade of service to customers.

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28-137

Abridgment of

Vector Presentation of Broad-Band Wave Filters

BY R. F. MALLINA* and O. KNACKMUSS*

Member, A. I. E. E. Non-member

Synopsis.—The function of a broad-band wave filter of the iterative ladder type in the attenuation band, and outside the attenuation band, can be explained very simply when expressed in terms of two characteristic vectors Z_a and Z_b. Drawing the diagram of these vectors, it becomes obvious that the angle between them is the phase shift of the filter and that the natural logarithm of the ratio of their magnitudes is the attenuation.

The diagram also shows very plainly the relationship between a mid-series and a mid-shunt structure, and the equations for such filters can be derived in a very simple manner from the geometry of one vector triangle.

It is hoped that this simplified presentation of types of filters which are so extensively used in radio, acoustical, and mechanical engineering will be helpful in understanding their physical meaning.

1.0 Broad-Band Filters of the Ladder Type in General

SUPPOSE we measure the impedance of a network as illustrated in Fig. 1 at the point 1, and obtain at the frequency f the value $Z_i = Z_k$. The impedance Z_i we call the input impedance; Z_k the iterative impedance.[1]

Then we cut off section a, measure the impedance at point 2, and obtain again $Z_i = Z_k$. Cutting off sections b and c and always obtaining the measurement $Z_i = Z_k$ shows that Fig. 1 is a network whose input impedance is equal to the terminating or iterative impedance.

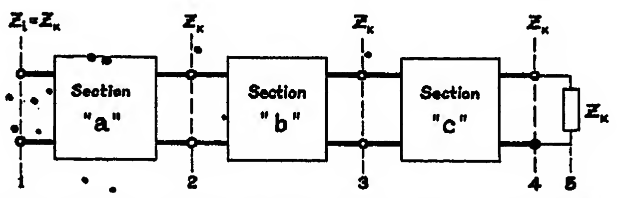


Fig. 1—General Arrangement of an Iterative Structure

A structure of this type is called an iterative structure. The broad-band wave filter of the ladder type is a special case of an iterative structure, and it is this type of filter with which this paper deals.

As will be seen later, it is necessary that with a change of frequency, the terminating impedance Z_k must be varied in a certain manner, so that at all times the input impedance Z_i is equal to Z_k.[2]

A broad-band wave filter structure will allow current to pass in a certain frequency band without attenuation, whereas outside this band the current is attenuated considerably.

This fact accounts for the name, filter.

1.1 Two Characteristic Types of Filter Sections. The following two types of filter sections will make Z_i equal to Z_k. The one is called a "mid-series section" (Fig. 2), and the other a "mid-shunt section" (Fig. 3.) The mid-series section Fig. 2 is also called a T section and the mid-shunt section Fig. 3 a π section. There are other special types of filter sections which, however, will not be considered in this paper.

2.0 The Mid-Series Filter Section

2.1 Input Impedance. That the input impedance Z_i of a mid-series filter section (Fig. 4) can be made equal to the terminating impedance Z_k is shown in the impedance diagram, Fig. 5.

For the purpose of our first illustration, let us choose conditions so that Z_k is a pure resistance.

Adding to the terminating impedance Z_k the series

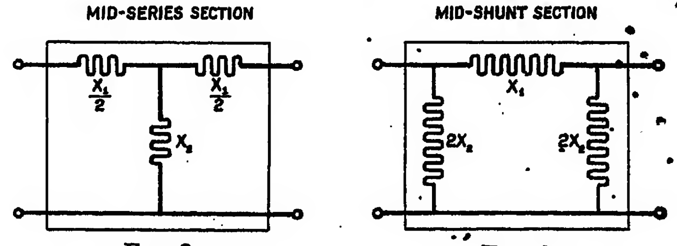


Fig. 2 Fig. 3

Figs. 2 & 3—Two Characteristic Types of Filter Sections

impedance $X_1/2$ the vector Z_a (Figs. 4 and 5) is obtained. The sum of the reciprocal of Z_a and the vector $1/X_2$ gives us the vector $1/Z_b$ whose reciprocal is then Z_b. Adding $X_1/2$ to Z_b we find that the resulting vector Z_i is equal to Z_k. In other words, having given Z_k and X_1 we choose X_2 to have a value such that $Z_i = Z_k$. The sequence of these operations is indicated in Fig. 5A.

Expressed in vector mathematics we have:[3]

*Of the Victor Talking Machine Co., Camden, N. J.

1. So far as possible the same symbols will be employed in this paper as are used in K. S. Johnson's "Transmission Circuits for Telephonic Communication." (A complete list of symbols appears in Appendix A, not included in Abridgment.)

2. In practise, of course, there is no such terminating impedance having the correct value at every frequency. However, it is possible to change certain elements of the network and obtain a close approximation to filter conditions.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Jan. 28-Feb. 1, 1929. Complete copies upon request.

3. The symbol | Z | indicates magnitude of Z. The symbol Z without the bars represents a vector having magnitude and direction.

$$\mathcal{Z}_k + \frac{X_1}{2} = Z_a$$

$$\frac{1}{Z_a} = \frac{|1|\,\epsilon^{j0}}{|Z_a|\,\epsilon^{j\beta/2}} = \frac{|1|}{|Z_a|}\,\epsilon^{j(-\beta/2)} = \frac{|1|}{|Z_a|}\,\backslash\!\beta/2$$

In other words, if Z_a is a vector with angle $\left(+\frac{\beta}{2}\right)$ the reciprocal $1/Z_a$ is a vector with angle $\left(-\frac{\beta}{2}\right)$

$$\frac{1}{Z_a} + 2\,\frac{1}{2\,X_2} = \frac{1}{Z_b}$$

$$Z_b + \frac{X_1}{2} = \mathcal{Z}_i$$

$$\therefore \boxed{\mathcal{Z}_i = \mathcal{Z}_k} \qquad (1)$$

These vector operations may be repeated for every filter section (Fig. 1) and the diagram (Fig. 5) will always remain the same. Therefore we may say in

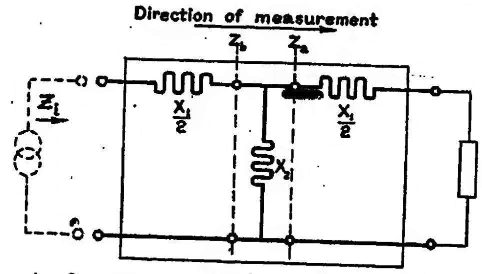


FIG. 4—CIRCUIT OF MID-SERIES FILTER SECTION

general terms that the input impedance $\mathcal{Z}_i$ is equal to the iterative impedance $\mathcal{Z}_k$ and this in turn is equal to the terminating impedance $\mathcal{Z}_k$ (Fig. 1 at points 1, 2, 3, and 4).

2.2 Iterative Impedance $\mathcal{Z}_k$. It is clear from the diagram in Fig. 5 that the vector $1/2\,X_2$ must be of such a value that the vector Z_a is in line with the vector $1/Z_b$. If this is not the case, the input impedance is not equal to the terminating impedance and the structure is not the iterative structure described in paragraph 1.1.

From the vector geometry of Fig. 5 we obtain:

$$\frac{X_1}{2} \div \frac{1}{2\,X_2} = Z_a \div \frac{1}{Z_b}$$

$$\therefore X_1\,X_2 = Z_a\,Z_b \qquad (2)$$

$$\boxed{Z_a = \mathcal{Z}_k + \frac{X_1}{2}} \qquad (3)$$

$$\boxed{Z_b = \mathcal{Z}_k - \frac{X_1}{2}} \qquad (4)$$

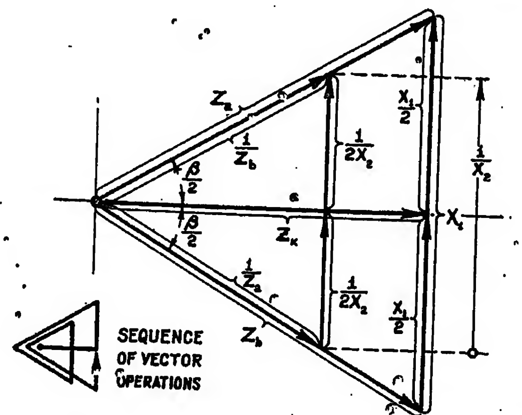
Substituting (3) and (4) in (2)

$$X_1\,X_2 = \left[\mathcal{Z}_k + \frac{X_1}{2}\right]\left[\mathcal{Z}_k - \frac{X_1}{2}\right] = (\mathcal{Z}_k)^2 - \left(\frac{X_1}{2}\right)^2$$

$$\mathcal{Z}_k = \sqrt{X_1\,X_2 + \left(\frac{X_1}{2}\right)^2}$$

$$\boxed{\mathcal{Z}_k = \sqrt{X_1\,X_2}\,\sqrt{1 + \frac{1}{4}\,\frac{X_1}{X_2}}} \qquad (5)$$

In Fig. 5, vector X_1 and vector $1/X_2$ have the $+j$ direction; such a structure is called a low-pass filter.



5A

FIG. 5—VECTOR DIAGRAM OF A MID-SERIES FILTER SECTION

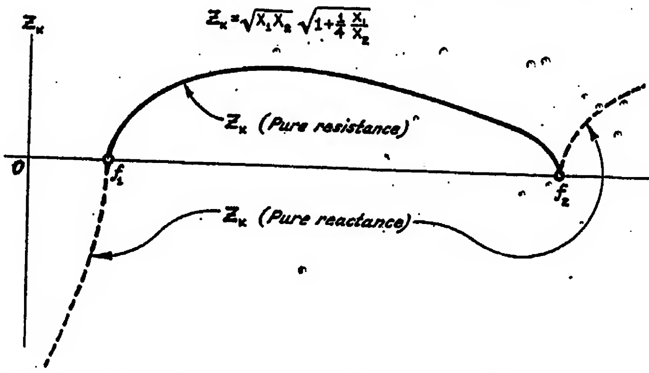


FIG. 6—ITERATIVE MID-SERIES IMPEDANCE OF ONE TYPE OF BAND-PASS FILTER

However, Equation (5) may also be obtained when X_1 and $1/X_2$ have the $-j$ direction. This structure is a high-pass filter.

In Equation (5) the reactances X_1 and X_2 are functions of frequency.

Taking the special case of a band-pass filter (Fig. 38A) we may plot Equation (5) and obtain a curve as illustrated in Fig. 6.

It appears from the figure that $\mathcal{Z}_k$ takes the value zero at two points on the frequency scale, one at f_1 and one at f_2. They are called the cut off frequencies. As will be seen later, between these cut-off points the current passes through the structure without attenuation, whereas it is considerably attenuated outside the frequency cut-off points.

2.3 Iterative Impedance $\mathfrak{Z}_k$ in Vector Diagram. How the impedance $\mathfrak{Z}_k$ is changed from a resistance into a reactance at the points f_1 and f_2 may be illustrated by using the vector diagram of Fig. 5 and varying the value of the impedance vectors X_1 and $1/X_2$ from zero to infinity.

Let us start with a frequency at which the angle β is

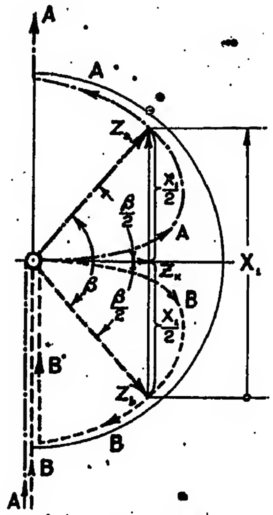


FIG. 7

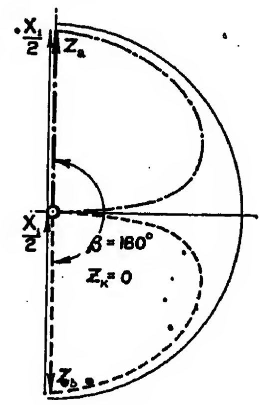


FIG. 8

FIG. 7—POSITION OF THE CHARACTERISTIC VECTORS Z_a AND Z_b IN THE FREQUENCY BAND

FIG. 8—POSITION OF THE CHARACTERISTIC VECTORS Z_a AND Z_b AT THE UPPER CUT-OFF FREQUENCY f_2

the angle enclosed by Z_a and Z_b in the band-pass filter diagram of Fig. 7.

By varying the frequency up and down (Equations (3) and (4)), the vector Z_a describes the dot-and-dash line, the vector Z_b the dash-line.

The arrows A and B indicate the directions in which the vectors Z_a and Z_b move when the frequency is increased.

If we increase the frequency, we get one limit for $\mathfrak{Z}_k$ as pure resistance when $\beta = 180$ deg. (Fig. 8).

Then

$$Z_a = -Z_b = \frac{X_1}{2} \tag{6}$$

or in other words, Z_a and Z_b are equal in magnitude but have opposite directions. $\mathfrak{Z}_k = 0$ in this case, as is obvious from Fig. 8.

If we decrease the frequency we get the other limit for $\mathfrak{Z}_k$ as pure resistance.

Then

$$Z_a = Z_b = \frac{X_1}{2} = 0 \tag{7}$$

2.4. Resistance and Reactance Limits of $\mathfrak{Z}_k$. The question is now, what happens to $\mathfrak{Z}_k$ when we have increased or decreased the frequency beyond these limits.

From Fig. 7 we can see that X_1 is the difference between the vectors Z_a and Z_b or

$$Z_a - Z_b = X_1 \tag{8}$$

also

$$Z_a = \mathfrak{Z}_k + \frac{X_1}{2} \tag{3}$$

$$Z_b = \mathfrak{Z}_k - \frac{X_1}{2} \tag{4}$$

These equations are also true for $\beta/2 = 90$ deg. Then $\mathfrak{Z}_k$ is zero or a pure reactance and we obtain a condition as shown in Fig. 9.

Fig. 10 represents Equations (8), (3) and (4) when $\beta = 0$.

If we let $X_1/2$ and $1/2\,X_2$ in Fig. 5 increase until $\beta = 180$ deg. and $\mathfrak{Z}_k = 0$, we obtain a vector diagram as shown in Fig. 11. From Fig. 5 it is obvious that assuming the angle β to be 180 deg.:

$$\frac{X_1}{2} = Z_a \tag{9}$$

$$\frac{1}{2\,X_2} = -\frac{1}{Z_a} \tag{10}$$

$$\frac{X_1}{X_2} = -4 \tag{11}$$

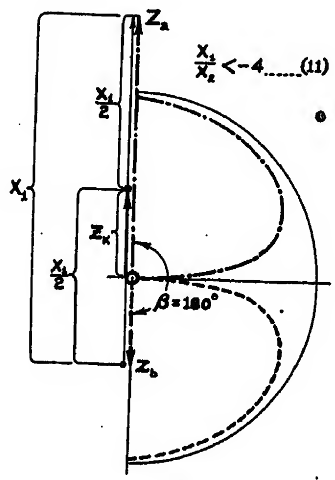


FIG. 9

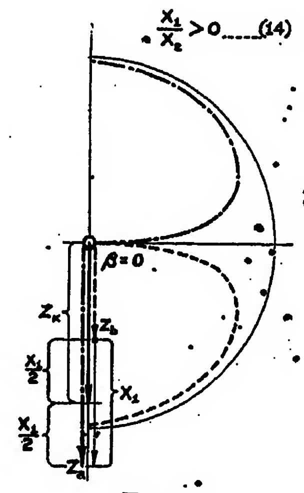


FIG. 10

FIGS. 9 & 10—POSITION OF THE CHARACTERISTIC VECTORS Z_a AND Z_b OUTSIDE THE FREQUENCY BAND

If we let X_1 in Figs. 5 and 7 decrease until $\beta = 0$, it is clear that

$$\frac{X_1}{2} = 0 \tag{12}$$

$$\frac{1}{2\,X_2} = 0 \tag{13}$$

$$\therefore \frac{X_1}{X_2} = 0 \tag{14}$$

In this way, we may say that assuming the vectors X_1 and X_2 the vector Z_k must be a pure resistance when X_1/X_2 is smaller than zero and greater then -4 (Fig. 7)

$$\boxed{0 > \frac{X_1}{X_2} > -4} \qquad (15)$$

Outside the band Z_k is a pure reactance.

Equations (11) and (14) determine the cut off points f_1 and f_2.

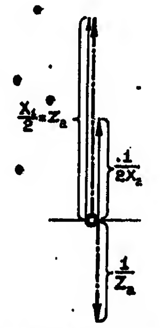


FIG. 11—POSITION OF THE VECTORS Z_a AND $1/Z_a$ AT THE UPPER CUT-OFF FREQUENCY f_2

2.5 Current Relations. So far, we have considered impedance relations of the network only. It will be interesting now to see how the current passes through a mid-series filter and what the phase shift and attenuation are at various frequencies.

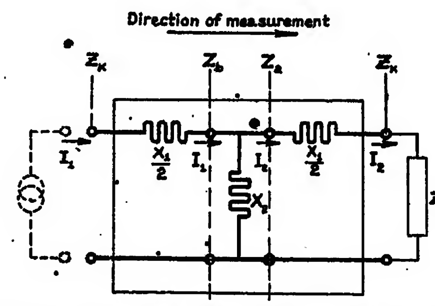


FIG. 12—CIRCUIT OF A MID-SERIES FILTER SECTION INDICATING CURRENT ENTERING AND LEAVING THE SECTION

From Fig. 12 we see that the voltage across Z_b is equal to the voltage across Z_a

$$I_1 Z_b = I_2 Z_a$$

$$\frac{I_1}{I_2} = \frac{Z_a}{Z_b} \qquad (17)$$

$$\therefore \frac{|I_1|}{|I_2|} = \frac{|Z_a|}{|Z_b|} \qquad (18)$$

This equation may be expressed in the exponential form and we obtain

$$\frac{|I_1|}{|I_2|} \equiv \epsilon^A = \frac{|Z_a|}{|Z_b|} \qquad (19)$$

$$\therefore \boxed{A = ln\frac{|Z_a|}{|Z_b|}} \qquad (20)$$

The index A is called the attenuation constant and is the natural logarithm of the ratio of the current magnitude entering the section to the current magnitude leaving it.

2.6 Phase Shift β. Since in the circuit Fig. 12, the current phase shift is equal to the angle between the current I_1 entering the section and the current I_2 leaving it, and since by (17)

$$\frac{I_1}{I_2} = \frac{Z_a}{Z_b} \qquad (17)$$

it is obvious that the angle β in Fig. 7 is the phase angle of the filter (Appendix B of the complete paper).

In Fig. 10, Z_a and Z_b have the same direction, $\beta = 0$, and $X_1/X_2 > 0$.

In Fig. 9, Z_a and Z_b have opposite directions $\beta = 180$ deg. and $X_1/X_2 < -4$.

In Fig. 7 the phase angle changes with Z_k.

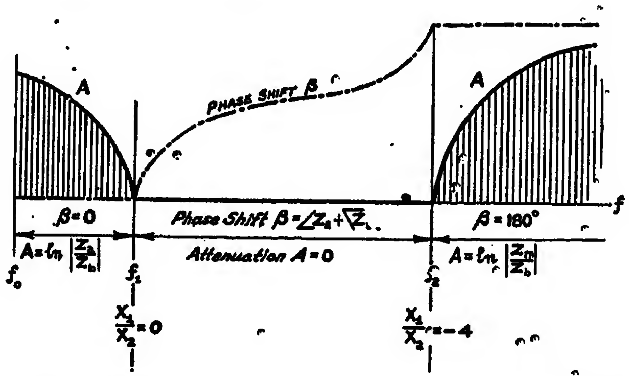


FIG. 13—ATTENUATION AND PHASE SHIFT OF ONE TYPE OF BAND-PASS FILTER

In general we may say that β is the angle between Z_a and Z_b.

$$\boxed{\beta = \angle Z_a + \setminus Z_b} \qquad (21)$$

Fig. 13 shows that the phase shift changes very abruptly near the cut off points.

2.7 Attenuation A. The attenuation in circuit Fig. 12 is zero when the magnitude of the current vector I_1 is equal to the magnitude of the current vector I_2. This is the case in Figs. 7 and 8.

By Equation (19)

$$\frac{|I_1|}{|I_2|} \equiv \epsilon^A = \frac{|Z_a|}{|Z_b|} \qquad (19)$$

Letting $|Z_a| = |Z_b|$ (Figs. 8 and 7).

then $A = 0$

In Figs. 9 and 10, Z_a and Z_b are different in magnitude and there will be attenuation of the current.

$$\frac{|I_1|}{|I_2|} = \frac{|Z_a|}{|Z_b|} = \epsilon^A \qquad (19)$$

$$\therefore A = ln\frac{|Z_a|}{|Z_b|} \qquad (20)$$

Assuming the special case of a band-pass filter (Fig. 38a) and plotting Equation (20) in terms of frequency, we obtain a curve which changes very abruptly near the cut-off point and which indicates that there is no attenuation in the frequency band between the cut off points f_1 and f_2 or between $X_1/X_2 = 0$, and $X_1/X_2 = -4$ (Fig. 13). Here is presented the basis of the statement made in paragraph 1.0 for definition of a broad-band iterative filter.

The attenuation $A = l \cdot n \mid Z_a/Z_b \mid$ and the phase shift $\beta = \underline{/ Z_a} + \sqrt{Z_b}$ can be readily expressed in functions of X_1 and X_2. (See Appendix C of the complete paper.)

The same method which was used to determine attenuation and phase shift for a mid series filter section may be applied to a mid shunt filter section.

Abridgment of

Transient Analysis of A-C. Machinery

BY YU H. KU*

Associate, A. I. E. E.

Synopsis.—This paper shows how the Heaviside operational methods may be applied to determine the transient currents that are produced in synchronous and induction machines by some sudden alteration of their electric circuits. The observed and computed values of the transient currents have been plotted for a number of cases. There is also a table giving the names of the principal investigators who have written on this subject, and the methods of analysis that they have employed.

During the last 15 or 20 years, the problem of calculating the transient currents in a-c. machinery has become increasingly important. Many notable papers on this subject have appeared in technical literature both in this country and abroad.

In the analysis of these transient problems it is necessary to make some assumptions, either in regard to the nature of the phenomena or in regard to the characteristics of the fundamental physical quantities involved. The earlier authors, such as Steinmetz and Boucherot, followed the first method, while the later authors with few exceptions have followed the second method. The important physical quantities involved are the resistances and inductances of the stator and rotor windings, and the characteristics of the magnetic circuit that enter into the determination of the eddy-current and hysteresis losses. It has been customary to assume that the resistances and self-inductances of the stator and rotor windings are constant, and that the mutual inductance between any two windings varies with the cosine of their relative angular displacement. These assumptions in regard to the inductances are practically equivalent to assuming that the air-gap is uniform and the flux in it, sinusoidally distributed. Whenever eddy currents have been considered, they have been assumed to exist in an electric circuit of constant resistance and self-inductance.

It seems appropriate to present at this time a brief summary of the technical literature by the principal investigators of these transient problems, indicating the type of solution and the essential features of the methods they have employed. These authors who adopted the foregoing or other reasonable assumptions in regard to the characteristics of the fundamental physical quantities, and those who have carried out the mathematical analysis with rigor, are said to have given an exact solution. All other solutions are classed as approximate. Thus, all cases where the resistances have been neglected or have been taken only partially into account,—as, for example, in determining values for the damping coefficients,—have been classed as approximate even though such solutions may have constituted very important and valuable contributions to this subject.

These transient problems are readily grouped in three general classes. In the first, the circuits on each side of the air-gap are symmetrical; in the second, the circuits on one side of the gap only are symmetrical, and in the third, the circuits on neither side of the gap are symmetrical. Exact solutions for problems in the first two classes can be obtained by operational methods, but those in the third class do not readily lend themselves to mathematical treatment, except in one special case.

In the accompanying table is given the summary of the methods employed by the principal investigators.

After the present investigation had been completed, the Heaviside operational solution by Bekku[1] was brought to the writer's attention. Bekku considered only the case of an alternator with symmetrical excitation, and so, in this slight respect, his solution differs from that presented by the author. In addition, the author believes that such a powerful method deserves to be more widely known than would be possible from Bekku's publication in a foreign journal.

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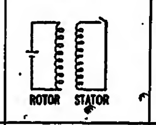
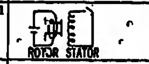
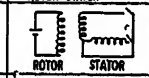
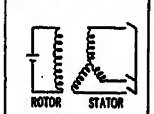
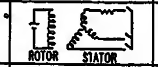
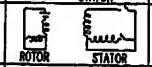
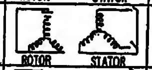
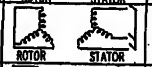
1. S. Bekku, "Sudden Short Circuit of an Alternator," *Researches of the Electrotechnical Laboratory*, No. 203, June 1927, Tokyo, Japan.

The following assumptions that have been made conform with the general practise: First it will be assumed that the stator windings are symmetrical and that the rotor is turning at constant speed; second, it will be assumed that the resistances and self-inductances of the windings are constant and that the mutual inductance between any two windings is proportional to the cosine of their relative angular displacement. Thus the effect of frequency upon resistance, the effect

TABLE I

CASE	DIAGRAM OF CONNECTIONS	AUTHOR OF SOLUTION		TYPE OF SOLUTION	ESSENTIAL FEATURES
III		Steinmetz Boucherot Berg Biermanns Doherty Shimidzu and Ito Otake	1909 1911 1915 1915 1918 1922 1924	Approximate Approximate Approximate Exact Approximate Approximate Exact	"Flux Theory" "E.M.F. Theory" For Special Case $r_a/L_a = r_f/L_f$ "Constant Flux Linkages Theorem" Resistances First Neglected. Mathematical
III[1]		Doherty and Nickle	1927	Approximate	Double-Reaction Method and Constant Linkages Theorem
II		Boucherot Laffoon Franklin	1911 1924 1925	Approximate Approximate	"Constant Flux Linkages" Doherty's Method
II		Steinmetz Arnold Diamant Dreyfus Lyon Laffoon Franklin	1909 1913 1915 1916 1923 1924 1925	Approximate Approximate Approximate Exact Exact Approximate Approximate	Boucherot's Method 'Vector' Method 'Vector' Method or Method of 'Shrinking Vectors'.
III		Karapetoff	1925	Approximate	Neglect Resistances
I[2]		Dreyfus	1912	Exact	Mathematical
I[2]		Rudenberg Bekku	1925 1927	Exact Exact	Dreyfus' Vector Method Operational
I		Doherty and Williamson Lyon Dreyfus	1921 1923 1911	Approximate Exact Exact	"M.M.F's. Considered and Const. Flux Linkages" "Shrinking Vectors" Vector Method
II[2]		Bekku	1927	Exact	Operational

1 Salient Pole Rotor 2 Symmetrical Field Excitation

of saturation upon inductance, and the effect of harmonics in the distribution of the air-gap flux density are neglected. It should be observed that these assumptions in regard to the inductances cannot be realized except when the machine has a cylindrical rotor. It must also be noted particularly that the solution as here presented does not apply unless the circuits on at least one side of the air-gap are symmetrical. For example, the method does not apply to the sudden single-phase short circuit of an alternator with the usual type of field excitation.

Briefly, this solution consists in applying first the Stokvis-Fortescue method of symmetrical phase components to reduce the polyphase relations to equivalent single-phase relations; second, an operational method, by which the equations that apply to the stator and rotor circuits and that recognize their relative angular velocity are transformed so that they become similar to the equations that apply to circuits which have no relative rotation; third, the Heaviside operational method, including the principle of superposition as applied to static circuits, employed to determine the integration constants in the solution.

THE OPERATIONAL METHOD

With the foregoing assumptions relative to the character of the resistances and inductances, superposition of currents is possible and the principle underlying Thévenin's[2] theorem can be used in determining the currents which flow when the terminals are suddenly short-circuited. Thus the current in any phase after the short circuit occurs can be considered as the sum of two components: first, that current which would exist if no disturbance occurred; and second, the additional current that would be produced by suddenly applying to the terminals an alternating e. m. f. equal and opposite to the potential existing there before the short circuit.

The operational equations for the alternator's response to the suddenly applied terminal e. m. fs. can be written as follows, reference being made to Fig. 1:

$$(R_1 + L_1\, p)\, i_a + M\, p\, [i_2 \cos n\, t] = v_a 1 \qquad (1)$$

$$(R_1 + L_1\, p)\, i_b + M\, p \left[i_2 \cos \left(n\, t - \frac{2\,\pi}{3} \right) \right] = v_b 1 \qquad (2)$$

$$(R_1 + L_1\, p)\, i_c + M\, p \left[i_2 \cos \left(n\, t - \frac{4\,\pi}{3} \right) \right] = v_c 1 \qquad (3)$$

$$(R_2 + L_2\, p)\, i_2 + M\, p \left[i_a \cos n\, t + i_b \cos \left(n\, t - \frac{2\,\pi}{3} \right) + i_c \cos \left(n\, t - \frac{4\,\pi}{3} \right) \right] = 0 \qquad (4)$$

Where

R_1 = resistance of stator, per phase.

R_2 = resistance of field.

L_1 = synchronous self-inductance of stator, per phase. It is the self-inductance of one stator phase, plus the mutual effect of each of the other stator phases.

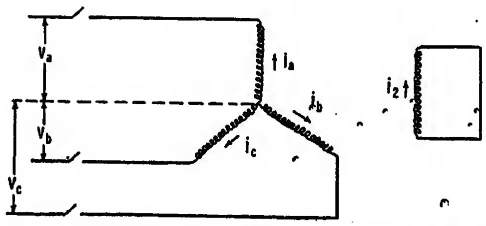


FIG. 1—CONNECTION FOR SUDDEN APPLICATION OF E. M. FS. TO ALTERNATOR TERMINALS

L_2 = self-inductance of field.

M = maximum value of the mutual inductance between one phase of the stator and the field winding.

i_a, i_b, i_c = instantaneous values of stator currents in phases a, b, and c.

i_2 = instantaneous value of field current.

2. L. Thévenin, "Sur un Nouveau Théorème D'Electricité Dynamique," *Comptes Rendus*, Vol. 97, 1883, pp. 159-161. While this theorem was written for the steady state, its extension to the transient case can be readily made.

v_a, v_b, v_c = instantaneous values of the stator terminal potentials in phases a, b, and c.

n = relative angular velocity between windings of stator and field.

$p = \frac{d}{dt}$, the time differential operator.

1 = unit function. In operational calculus notation this means a time function which is discontinuous at $t = 0$, being zero before and unity thereafter.

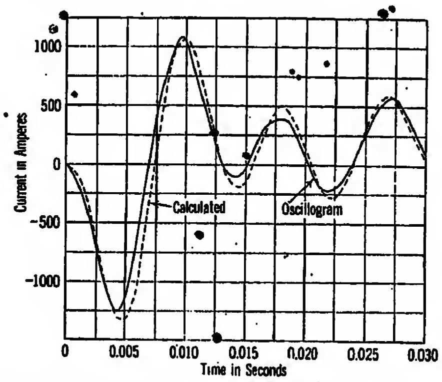


FIG. 2—POLYPHASE SHORT CIRCUIT OF ALTERNATOR AT NO-LOAD CURRENT TRANSIENT IN PHASE A

The full lines represent oscillograph records and the dotted lines the calculated values

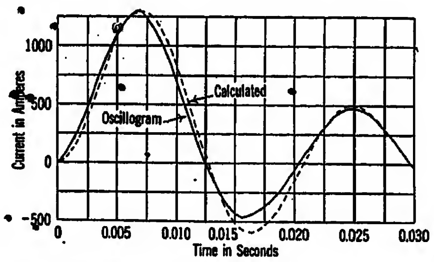


FIG. 3—FIELD CURRENT TRANSIENT CORRESPONDING TO CASE OF FIG. 2

The full lines represent oscillograph records and the dotted lines the calculated values

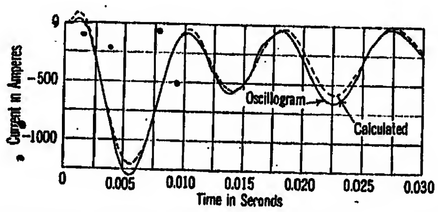


FIG. 4—POLYPHASE SHORT CIRCUIT OF ALTERNATOR HAVING UNITY POWER FACTOR LOAD. CURRENT TRANSIENT IN PHASE a

The full lines represent oscillograph records and the dotted lines the calculated values

If the stator potentials are balanced, the e. m. fs. which are applied to the terminals will also be balanced, so that the sum of their instantaneous values is zero. With no neutral connection, the sum of the instantaneous values of stator currents will also be zero; consequently (3) is obtainable from (1) and (2) and need not be considered further, and (4) can be reduced to an equation in i_2 and the two phase currents i_a and i_b.

By means of the Stokvis-Fortescue scheme[3] of symmetrical component analysis the phase currents and voltages can be replaced by their positive- and negative-sequence components, and the same can be done with the induced e. m. fs. due to the mutual induction. When (1), (2), and (4) are rewritten to include these various relationships, they become

$$(R_1 + L_1 p)(i_+ + i_-) + (e_+ + e_-) = (v_+ + v_-) 1 \quad (5)$$

$$(R_1+L_1 p)(i_+ a^2+i_- a)+(e_+ a^2+e_- a) = (v_+ a^2+v_- a) 1 \quad (6)$$

$$(R_2 + L_2 p) i_2 + \frac{3}{2} M p (i_+ \epsilon^{-jnt} + i_- \epsilon^{jnt}) = 0 \quad (7)$$

where a and a^2 are $\epsilon^{j\frac{2\pi}{3}}$ and $\epsilon^{j\frac{4\pi}{3}}$ respectively. Solving (5) and (6) simultaneously for v_+ and v_-, and inserting the exponential forms for e_+ and e_-, these two equations reduce to

$$(R_1 + L_1 p) i_+ + \frac{M}{2} p i_2 \epsilon^{jnt} = v_+ 1 \quad (8)$$

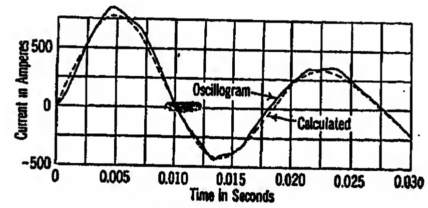


FIG. 5—FIELD CURRENT TRANSIENT CORRESPONDING TO CASE OF FIG. 4

The full lines represent oscillograph records and the dotted lines the calculated values

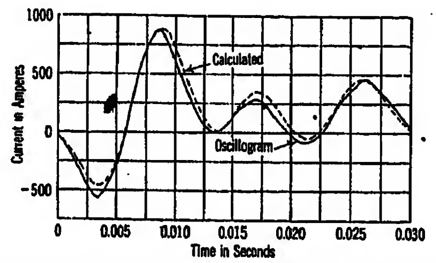


FIG. 6—POLYPHASE SHORT CIRCUIT OF ALTERNATOR HAVING LAGGING POWER-FACTOR LOAD. CURRENT TRANSIENT IN PHASE a

The full lines represent oscillograph records and the dotted lines the calculated values

$$(R_1 + L_1 p) i_- + \frac{M}{2} p i_2 \epsilon^{-jnt} = v_- 1. \quad (9)$$

If (8) is multiplied by ϵ^{-jnt}, and (9) by ϵ^{jnt}, and these exponentials in every case are shifted to the right

3. L. G. Stokvis, "Sur la Création des Harmoniques 3 dans les Alternateurs par Suite du Déséquilibrage des Phases," *Comptes Rendus*, 159, 1914, pp. 46-49. L. G. Stokvis "Analysis of Unabalanced Three-Phase Systems, *Electrical World*, 65, 1915, pp. 1111-15. R. E. Gilman and C. L. Fortescue, *Single-phase Power Service from Central Stations*, A. I. E. E. TRANS., Vol. XXXV, 1916, pp. 1329-1347. C. L. Fortescue, *Method of Symmetrical Coordinates Applied to the Solution of Polyphase Networks*, A. I. E. E. TRANS., Vol. XXXVII, 1918, pp. 1027-1115.

of the terms containing p by means of the operational shifting transformation,[4] there is obtained

$$[R_1+L_1(p+jn)]\,i_+\,\epsilon^{-jnt}+\frac{M}{2}(p+jn)i_2=v_+\,\epsilon^{-jnt}\,1 \quad (10)$$

$$[R_1+L_1(p-jn)]\,i_-\,\epsilon^{jnt}+\frac{M}{2}(p-jn)i_2=v_-\,\epsilon^{jnt}\,1 \quad (11)$$

These two, along with (7), form a set of linear equations

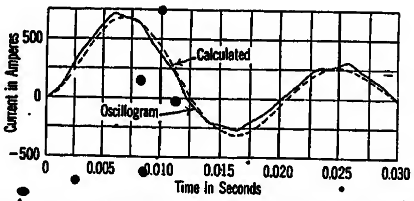


Fig. 7—Field Current Transient Corresponding to Case of Fig. 6

The full lines represent oscillograph records and the dotted lines the calculated values

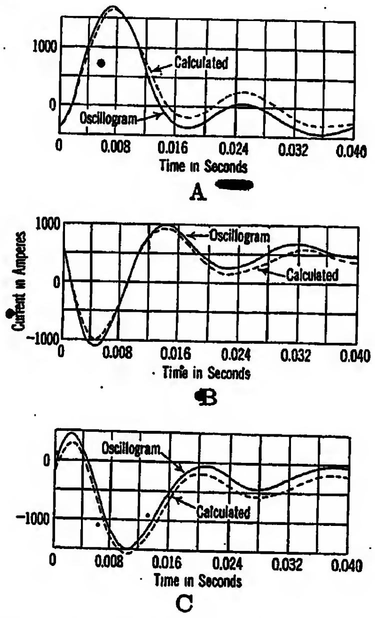


Fig. 8-a, b, c—Polyphase Short Circuit of an Induction Motor. Stator Currents

The full lines represent oscillograph records and the dotted lines the calculated values

in the variables $i_+\,\epsilon^{-jnt}$, $i_-\,\epsilon^{jnt}$, and i_2 which can be solved simultaneously to obtain expressions for each. Thus by a convenient choice of variables, the alternator equations written with a variable mutual inductance to care for the relative rotation between the windings of field and stator can be reduced to those of equivalent stationary circuits.

The expressions obtained for $i_+\,\epsilon^{-jnt}$, $i_-\,\epsilon^{jnt}$ and i_2 will be in terms of the physical constants of the machine and the algebraic quantity p, and thus may be considered operators of the Heaviside form operating upon the unit time function. At this point, the process of solution reduces to the conventional operational problem of interpreting the result of an operator applied to the unit function. A convenient way of making this interpretation in this case is by means of the Heaviside expansion theorem.[5] The results of this evaluation are explicit time functions for each of the three variables.

The rotational features can be returned to the problem by solving the explicit expression for i_+, i_-, and i_2; whereupon the first two can be combined in proper relation to determine the phase currents i_a, i_b, and i_c.

Some results of using this method of calculating the transients of synchronous and induction machines following symmetrical disturbances are given in the accompanying figures. In each case, comparison is

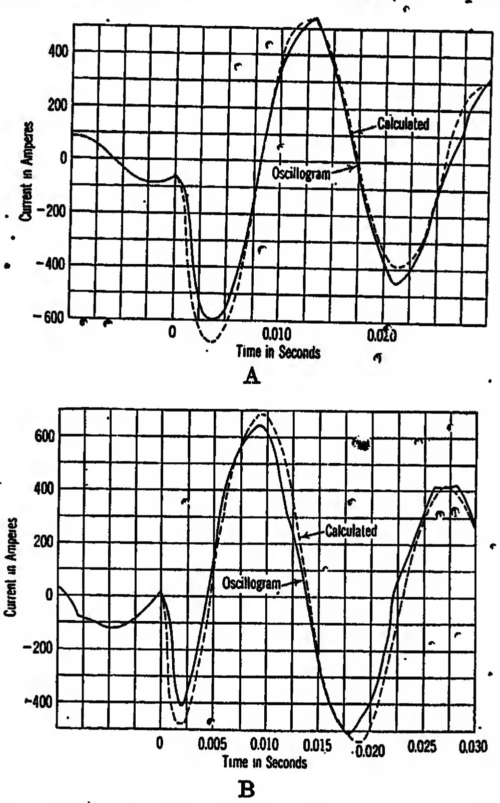


Fig. 9-a, b—Sudden Voltage Reduction at Induction-Motor Terminals. Stator Currents

The full lines represent oscillograph records and the dotted lines the calculated values

given between calculated curves and oscillograph records. The agreement between computed and observed values is seen to be quite satisfactory.

Acknowledgment

The author wishes to acknowledge his indebtedness to Professor V. Bush and Doctor B. A. Behrend for their suggestions and encouragement; and particularly to Professor W. V. Lyon and Professor M. F. Gardner, who have revised the paper for publication. Credit is also due to those former graduate students of the Massachusetts Institute of Technology whose theses were the source of helpful experimental results.

4. O. Heaviside, "Electromagnetic Theory," Vol. II, p. 294. V. Bush, "Operational Circuit Analysis," (Wiley), 1929, Ch. VIII, Sec. 10.

5. L. Cohen, "The Heaviside Expansion Theorem," *Jour. Franklin Inst.*, 194, 1922, pp. 765-770. V. Bush, *loc. cit.*, Chap. VII, Sec. 4.

Abridgment of

The Condenser Motor

BY BENJAMIN F. BAILEY[1]

Fellow, A. I. E. E.

Synopsis.—After a brief description of the construction and connections of the condenser motor, the necessity of varying the capacitance is discussed and the performance at start and under load considered. Locus diagrams illustrating the operating performance in detail are given, followed by a more detailed discussion of starting torque. The Appendix gives the mathematical derivation of many of the formulas discussed.

THE connections of a single-phase condenser motor are shown in Fig. 1. The motor itself is identical with a two-phase induction motor with the exception of the fact that the two windings are not necessarily alike. Winding 2 may have more or less turns than winding 1. The total weight of copper in the two, however, is approximately the same. The rotor is identical with that of any polyphase motor. It

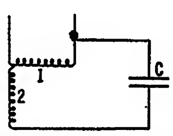


FIG. 1—SIMPLE CONDENSER MOTOR

usually is of squirrel-cage type, although a wound rotor may of course be used.

To obtain the best results, the capacitance should be large when the motor is being started and should be gradually reduced as the speed is increased. In practise, a fixed value of capacitance may be satisfactory,

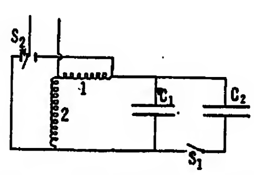


FIG. 2—CONDENSER MOTOR, REVERSIBLE AND WITH VARIABLE CAPACITANCE

providing a starting torque of about 50 per cent of full-load running torque is sufficient. If more starting torque is necessary, the motor may be connected as shown in Fig. 2. The switch S_1 is closed when the motor is at rest and is opened (usually automatically) when the speed is sufficiently high. Fig. 2 also illustrates a method by which the direction of rotation of the motor may be reversed by throwing the switch S_2 to the right or left.

Instead of using two condensers, it is possible to supply the condensers through a variable ratio transformer as shown in Fig. 3. By applying a high voltage to the condenser at start and a smaller voltage for running, the same effect is produced as though the capacitance was changed. With this scheme, the efficiency will necessarily be a little lower due to the losses in the transformer.

The vector diagram of a condenser motor is shown in Fig. 4. This was plotted from an actual test of a small motor under full load. In this case, the motor was a standard two-phase motor.

As usual, the current I_1 in phase 1 lags, by a con-

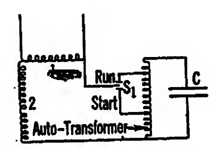


FIG. 3—CONDENSER MOTOR WITH VARIABLE TRANSFORMER

siderable angle behind the line voltage E. Due to the introduction of the condenser, the current I_2 in phase 2 may be made to lead the line voltage. When the proper capacitance is used, the two currents are approximately at right angles to one another and if the two windings are alike, are nearly equal. Under these

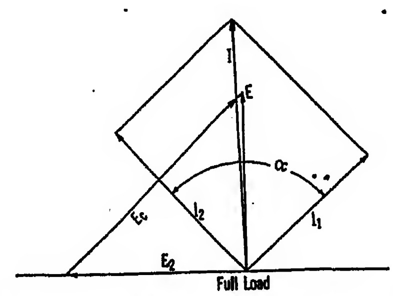


FIG. 4—VECTOR DIAGRAM OF CONDENSER MOTOR. (FULL LOAD)

conditions, the motor will operate just as though it were a two-phase motor and of course with the same efficiency.

From the above it will be apparent that we can build a single-phase motor having at full load practically the same efficiency as a two-phase motor and operating at or near 100 per cent power factor. It is self-evident that its characteristics will be much better than those of a single-phase motor of the usual construction which

1. Professor of Electrical Engineering, University of Michigan, Ann Arbor, Mich.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Jan. 28-Feb. 1, 1929. Complete copies upon request.

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necessarily operates at a lower efficiency and power factor than a two-phase motor.

In the starting performance, the condenser motor is somewhat superior to the two-phase motor. Since one current leads and the other lags, the combined starting current is the vector sum of the two and is less than their arithmetical sum. For the same reason, the power

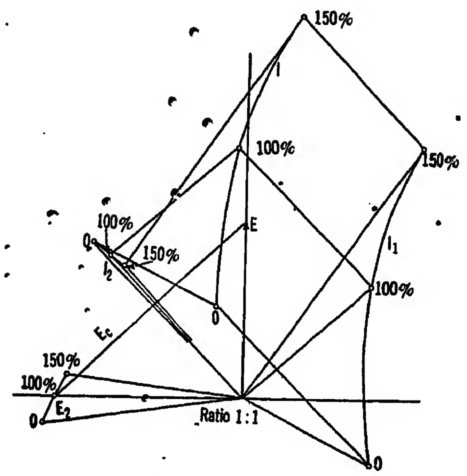

Fig. 7—Locus Diagram of Condenser Motor. Winding Ratio 1 to 1

factor is excellent and is usually close to 100 per cent. The motor will develop even more torque than a two-phase motor and the current required is substantially less; in fact, the torque per ampere is nearly double that of a two-phase motor.

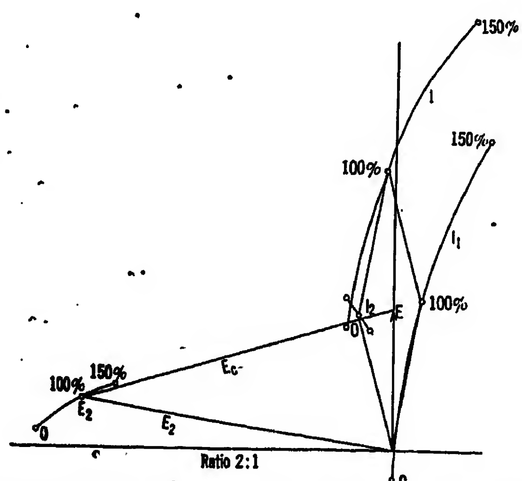

Fig. 8—Locus Diagram of Condenser Motor. Winding Ratio 2 to 1

Locus Diagrams

The action of the motor under varying loads is shown in the locus diagram of Fig. 7. The curve marked I_1 represents the locus of the vector I_1 as the load is changed. The small circles represent the positions of the end of the vectors corresponding to no-load, full load, and 50 per cent over load. Similarly, the short curves marked E_2 and I_2 represent the loci of the vectors representing the voltage across phase 2 and the current in phase 2. The curve marked I is the locus of the line current. In this particular case the current was leading at light load, in phase with the voltage at a little over full load, and slightly lagging for 50 per cent over load. The power factor throughout this range of load was very close to 100 per cent.

Fig. 8 shows a locus diagram for the same motor but connected so that phase 2 has twice as many turns as phase 1. The voltage across phase 2 is of course nearly twice as great as before. The condenser voltage obtained by drawing a line from any point on the curve E_2 to the end of the vector E is more nearly at right angles to E than before. Since the current I_2 must be at right angles to the condenser voltage, it is brought more nearly into phase with E. Since the capacitance used was such as to give nearly 100 per cent power factor to the motor as a whole, it follows that the current I_1

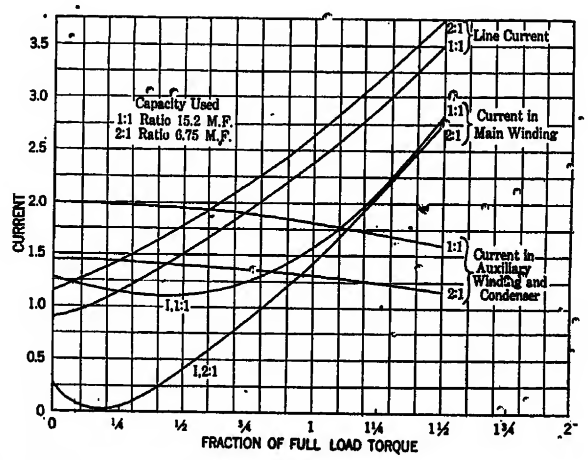

Fig. 9—Torques and Currents in the Different Windings of Condenser Motor

was forced to be more nearly in phase with the line voltage. The vector sum of the two is represented by the current I (the line current), and this is at nearly 100 per cent power factor throughout the range of the motor.

The advantage of having more turns in winding 2 than in winding 1 is that a higher voltage is applied to the condenser, and consequently, the capacitance can be greatly reduced; in fact the condenser used in making the tests represented in Fig. 8 was approximately one-half as large as that used in the tests of Fig. 7. It will of course be apparent that since the two currents I_1 and I_2 are no longer at right angles the motor is not operating so efficiently. In fact, the conditions approach those of the ordinary single-phase motor, since the current I_1 and I_2 do not differ very greatly in phase. The power factor is still excellent, but the efficiency of the motor is somewhat reduced.

Fig. 9 has been plotted from the same data used in Figs. 4 to 8, and shows the variation of the various currents with the torque. Similarly, Fig. 10 shows the

variation of the $I^2 R$ losses in the different windings.

Comparison of Watts

In Fig. 11 the total watt input to the motor, and also the watts in each of the windings, have been plotted. The watts in the auxiliary winding are nearly the same with either connection, and decrease only slightly as the load increases. The watts in the main winding are in both cases negative with light loads and of course increase as the load increases. The total power re-

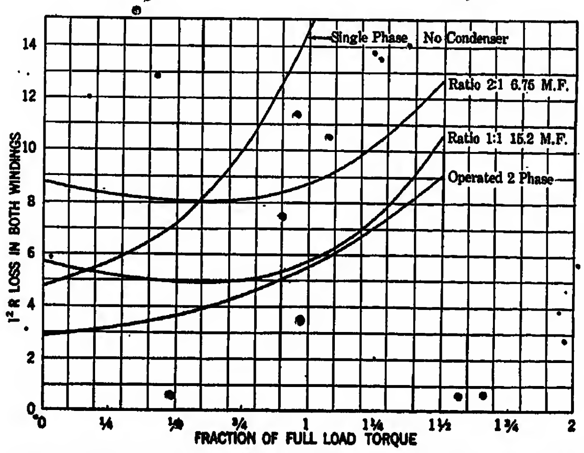

Fig. 10—Torque and $I^2 R$ Losses in Condenser Motor

quired with the two to one connection is greater than with the one to one connection on account of the reduced efficiency.

Effect of Changing Capacitance

It will be evident from the preceding discussion that the characteristics of a motor will be radically modified by any change in capacitance. The results of a test upon the same motor, previously referred to, have been embodied in Fig. 12, which shows the cur-

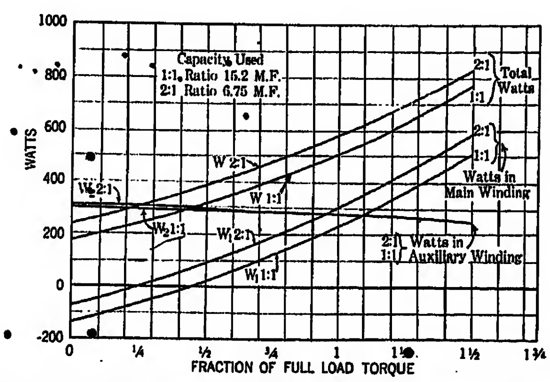

Fig. 11—Torques and Watts in Condenser Motor

rents plotted in their proper phase relation, the output being held constant while the capacitance was varied.

It will be noted in both of these curves that the power component of the current,—that is, the projection of the current upon the voltage axis,—is less with the current somewhat lagging than it is with 100 per cent power factor. At full load the minimum power input, and consequently the highest efficiency, is obtained with a capacitance of about five microfarads, and at half load with about three microfarads. The lowered efficiency, as previously explained, is due to the fact that the current does not divide between the two windings in the best ratio. In general, therefore, the capacitance which gives the best power factor will not necessarily be that which gives the highest efficiency. Particularly in the case of motors with a large number of turns in winding 2 compared with winding 1, it will be necessary to use a capacitance giving a somewhat lagging current if the best efficiency is to be obtained. With a one to one ratio, the points of best power factor and best efficiency will usually come more nearly together.

Starting Torque

As shown in the appendix the starting torque is given by the equation

$$T = Q\, N_1\, N_2\, I_1\, I_2 \sin \alpha.$$

The maximum current will exist in circuit 2 when the circuit is in resonance but under these circumstances the angle between the two currents will be unfavorable

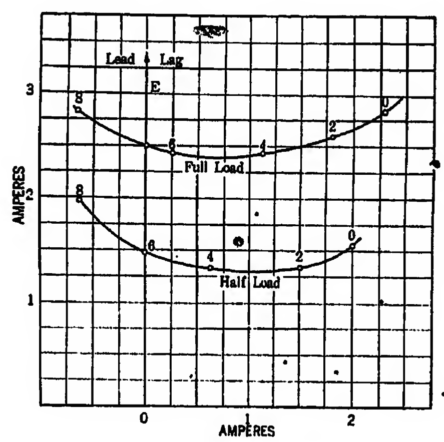

Fig. 12—Locus Diagram of Condenser Motor. Variable Capacitance and Constant Output. Winding Ratio 2 to 1

and consequently the greatest possible torque will not be developed.

It is shown in the Appendix (in the complete paper) that the maximum starting torque is obtained when

$$X_3 = \frac{1}{C\,\omega} = -K^2 Z_1$$

in which Z_1 is the impedance of circuit 1, C is the capacitance of the condenser in farads, and $\omega = 2\pi f$. K is the ratio of turns in winding 2 to the turns in winding 1.

The negative sign indicates that the reactance X_3 is due to a condenser and not to a reactor. If we should use a reactor of the same value it would give us another but much smaller maximum value of torque. In the following the negative sign will be ignored when we are dealing with capacitance only. If the two windings are formed with coils of the same dimensions and if

they contain the same weight of wire, the resistances, inductances, and impedances will all be in the ratio of K^2, K being the ratio of the turns in winding 2 to those in winding 1.

In the above formula, then, $K^2 Z_1$ is the impedance of winding 2, and for maximum torque this impedance should be equal to the reactance of the condenser. On the other hand the condition for resonance would be that the reactance of winding 2 should equal the reactance of the condenser.

It is shown in the Appendix, that the locked torque is given by the following equation,

$$T = \frac{K N_1^2 E^2}{Z_1^2} \cdot \frac{R_1 C \omega}{K^4 Z_1^2 C^2 \omega^2 - 2 K^2 X_1 C \omega + 1}$$

in which the symbols have the same significance as before.

Using the capacitance to give maximum torque; namely, $C = \dfrac{1}{K^2 Z_1 \omega}$, we obtain the following for the maximum torque with any given ratio of turns:

$$T_m = \frac{N_1^2 E^2}{2 K Z_1^2} \cdot \sqrt{\frac{Z_1 + X_1}{Z_1 - X_1}}$$

Relation of Torque and Volt-Amperes in the Condenser

As shown in the appendix, the equation for torque may be written as follows:

$$T = \frac{K N_1^2 R_1}{Z_1^2} E_c I_c = \frac{K N_1^2 R_1}{Z_1^2} \cdot E_c I_2$$

In other words, the torque is directly proportional to the product of the volts across the condenser and the current flowing in it.

If we insert the values of the constants of this particular motor, we obtain the equation

$$T = 0.116 \, K \, E_c \, I_2$$

The test results on this motor have been plotted with reasonably good correspondence between them and the calculated results.

The variation of the voltage across the condenser as we change the capacitance is also shown in the curves of Fig. 13. The voltage for any ratio between the turns is the same as the line voltage for $C = 0$, rises rapidly as C is increased up to the point of resonance; and then decreases. As we should expect from the theory the maximum torque is found with a value of C somewhat greater than that which gives resonance.

However, the condenser voltage at maximum torque is usually decidedly above line voltage.

The condenser voltage at the point of maximum torque is given by the following formula:

$$E_c = - E \sqrt{\frac{Z_1}{2 (Z_1 - X_1)}}$$

It will be seen that this value is independent of the ratio K, and in the case of this particular motor, the computed value is 274 volts. The actual values agreed fairly well with this, being 260 where $K = 1$ and 280 volts where $K = 2$.

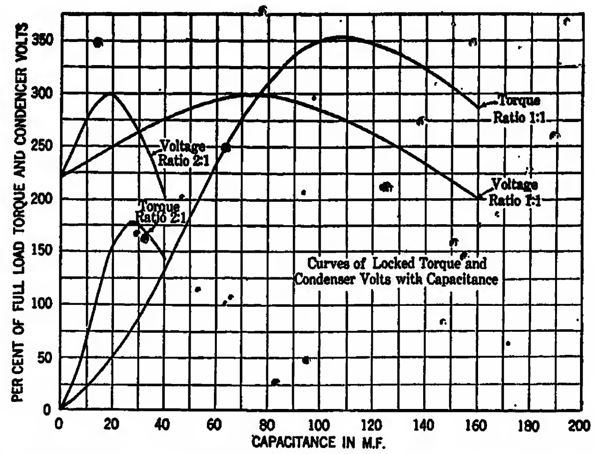

Fig. 13—Variation of Torque and Condenser Voltage with Capacitance

Summary

From the preceding, it will be obvious that as we increase the number of turns in winding 2, the maximum locked torque decreases. However, the capacitance needed decreases even faster, so that if locked torque only is to be considered, the ratio K of the turns should be as great as possible and still permit the necessary torque to be developed.

It will also be apparent from the equation for maximum torque that this may be made as great as desired provided we make K small enough. Excessive torques are however obtained at the expense of large currents and excessive cost of condensers.

Starting Efficiency

The efficiency of the motor increases with the torque and reaches higher values with the smaller values of the ratio K. The maximum efficiency obtained was 45 per cent.

Complete Torque Curves

In the actual application of the motor, we need to know not only the locked starting torque but the torque throughout the complete range of operation. Fig. 16 shows speed—torque curves for another motor with a ratio of turns of 1 to one and with various values of capacitance. It will be seen that the torque with the large values of capacitance is substantially maintained until the motor has reached normal operating speed. As the capacitance becomes smaller, there is a greater tendency toward development of points of low torque at certain speeds. This will be particularly apparent in the curve for 20 μ f. The point of lowest torque occurs at about one-seventh of synchronous speed and would seem to indicate the presence of a backwardly rotating 7th harmonic.

The curve of current taken when a 40-μ f. condenser was used also plotted. It will be seen that the current remains nearly constant throughout the entire starting period.

Abridgment of

Theoretical and Field Investigations of Lightning

BY C. L. FORTESCUE[1] A. L. ATHERTON[1] and J. H. COX[1]
Fellow, A. I. E. E. Member, A. I. E. E. Associate, A. I. E. E.

Synopsis.—This paper gives a review of some recent developments in the methods of studying lightning phenomena. The Norinder form of cathode ray oscillograph and its application in Tennessee are discussed, together with the information secured.

The second part gives the theory of traveling waves along transmission lines. Reflections at open and grounded ends are considered. A mirror scheme of an infinite series of waves on a double infinite line equivalent to actual waves along a finite line is developed.

The third part discusses the manner in which surges are actually produced on lines by lightning and the effect of ground resistance on the protection afforded by ground wires, both with respect to induced and direct strokes.

The Importance of Lightning Research. During the last few years the increasing importance of the solution of the lightning problem in electrical systems, particularly in long transmission circuits, has resulted in a tremendous increase in the amount of attention given the problem all over the world. Electrical systems are being reconstructed with the idea of generation in large plants at the most economic point, and interconnection between such plants and this added to the natural growth involves expenditures in the central station industry of nearly a billion dollars a year, of which possibly 150 million dollars a year is expended for transmission circuits. Under the present conditions lightning has been found to be the operating condition which limits the design of transmission circuits. The electrical industry must accept the fact that these enormous expenditures warrant fully whatever research expenditure and effort may be necessary to provide the solution to the lightning problem.

I. RECENT DEVELOPMENTS IN FIELD INVESTIGATIONS OF LIGHTNING

Application of Cathode Ray Oscillograph. Since the first introduction of cathode ray oscillographs into laboratory study of transient phenomena, it has been realized that this instrument would be ideal for the determination of the character of lightning voltages in exposed circuits. However, there have been barriers to this use of the cathode ray oscillograph which seemed at the start to be insurmountable. The major difficulty has been in providing means for having the oscillograph in operation on the arrival of the transient. It is essential to the solution of the problem to secure records of the entire duration of the abnormal voltages, and particularly of the beginning of the wave fronts. Thus, if means are devised to anticipate a transient which may occur at any time, it is necessary that the oscillograph be started by the transient itself and with zero delay. This is a problem of no small magnitude.

The Norinder Cathode Ray Oscillograph. In 1927 it came to our attention that successful work had been done by Doctor Harald Norinder of the Swedish Royal Board of Waterfalls, Upsala, Sweden, in making cathode ray oscillograms of actual lightning voltages.[2] It proved that Doctor Norinder's results had been secured by means of an ingenious improvement over the previously known forms of cathode ray oscillographs by which operation is made entirely automatic on the arrival of the transient. Fig. 5 illustrates the scheme invented by Doctor Norinder.

Use of Norinder Oscillographs in Field Studies.

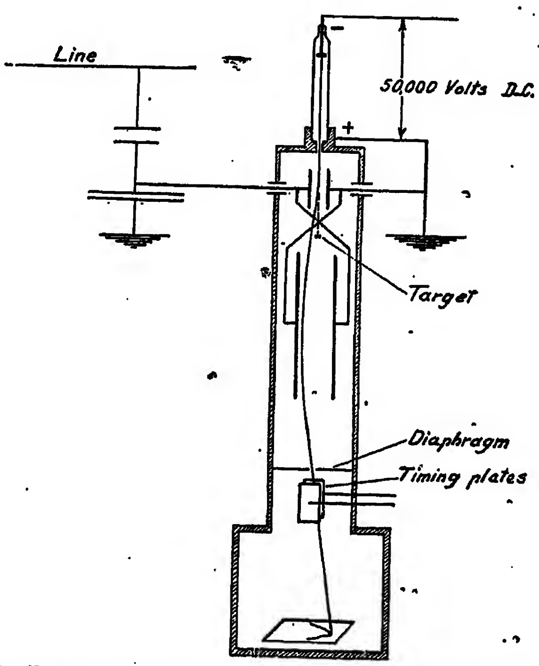

FIG. 5—DIAGRAMATIC SCHEME OF NORINDER OSCILLOGRAPH

Laboratory trials substantiated the experience of Doctor Norinder in establishing the usefulness of the instrument. It was felt to be necessary, however, to get the final assurance by a trial installation in the field that the instrument will give all the information which

1. All of the Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Jan. 28-Feb. 1, 1929. Complete copies upon request.

2. Dr. Harald Norinder, "Some Electrophysical Conditions Determining Lightning Surges," *Journal Franklin Institute*, June 1928.

Dr. Harald Norinder, *The Cathode Ray Oscillograph as Used in the Study of Lightning and Other Surges on Transmission Lines*, A. I. E. E. Quarterly TRANS., Vol. 47, No. 2, p. 446.

is needed. Arrangements were accordingly made for an installation of two instruments in Tennessee and a second installation of a single instrument in Illinois.

The Tennessee location was chosen, as it met the requirements of a test for this purpose—a highly insulated line in a territory where lightning storms are very frequent. A detailed survey of the operating record and of the location showed that the most suitable point on the line would be where it passes over the western end of the Chilhowee Ridge of the Great Smoky Mountains. Through the cooperation of the Knoxville Power Company and the Aluminum Company of America, arrangements were made for locating two stations, one on each side of the Chilhowee Ridge.

The general arrangement of the test stations is indicated by the diagram of Fig. 7.

The oscillographs and accessories were designed and built during the period between January and about the first of June, 1928. Installations in the field were completed by the early part of July, and from this time, the stations were ready to record any lightning which occurred.

It was planned to make the first few records using the rotating film in order to get a general picture of the nature of the surges and then to take later records using the oscillator for the time scale deflections. Unfortunately, however, only a single disturbance of appreciable magnitude appeared on the line during the period between the time when the apparatus was set up until November 4 when the test was discontinued for the year. This record is shown in Fig. 13. No

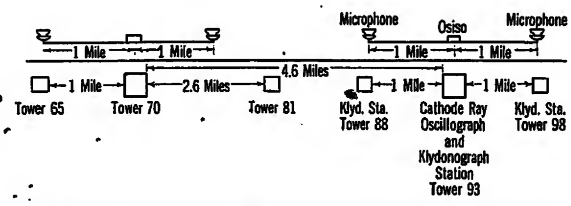

Fig. 7—Layout of Test at Chilhowee, Tenn.

voltage was recorded on either the klydonographs or the oscillographs at the other station, 4½ mi. away.

The storm conditions were observed by the operators, and the following general ideas developed: There were many discharges between clouds apparently directly over, or nearly over, the line without causing any line disturbances of sufficient magnitude to be recorded by either klydonograph or oscillograph. Strokes to earth were observed in the near vicinity of the line without causing any voltage of sufficient magnitude to make either klydonograph or oscillograph records. The particular stroke which gave the record shown in Fig. 13 was observed by one of the operators to be extremely close to the station but later examination did not show the exact place where it struck the earth.

Accomplishments of the First Year's Work. Perhaps the accomplishment of greatest importance resulting from the work during this summer is the demonstration that complete oscillograms of lightning voltages can be secured by the use of the Norinder form of cathode ray oscillograph. The klydonograph record shows that during the test only one voltage of appreciable magnitude occurred on the line at an oscillograph station. A complete oscillogram of this surge was secured; it shows the beginning, the entire wave front, the crest, and the entire duration of the transient.

A second finding of major importance is that any large number of serious overvoltages at any one point on a line during a single season is not to be anticipated. This fact, also, has been indicated by the previous

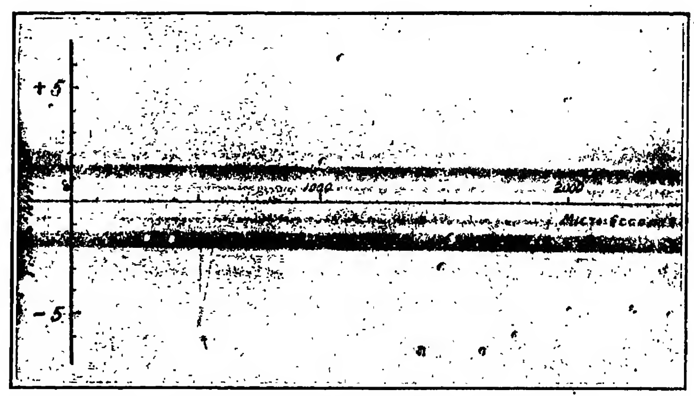

Fig. 13—Oscillogram of Lightning Surge on Transmission Line. 750 Kv.

extensive work with the klydonograph. Its significance in connection with lightning research is that it will be necessary to make a considerable number of installations and to operate them for several years in order to secure records covering the entire range of lightning voltages and operating conditions for various territories.

Need for Coordination of Effort. It is the plan to continue the tests in Tennessee, and probably several more instruments will be installed during the next season at other locations. In course of time, with the proposed program, we could obtain sufficient data to determine the characteristics of lightning waves so that their effect on transmission lines and connected apparatus could be predicted, and improvements in design and construction would result. However, due to the necessarily limited scope of our work or that of any other similar group, the time required to carry out the necessary program would be more than the electrical power industry would care to countenance for an investigation even so vital to the future of power development. When we consider that the annual expenditure of the industry in transmission is of the order of 150 million dollars, it seems clear that there is ample justification for spending the million dollars or so, necessary for adequate lightning research.

The work reported here demonstrates that the means necessary for obtaining a complete solution of the first part of the lightning problem are available. Similar work being conducted by other groups along somewhat different lines will doubtless result in availability of equally satisfactory means. The problem cannot be solved by either the manufacturers or operators working alone nor properly by any small group. The solution requires the financial and technical support

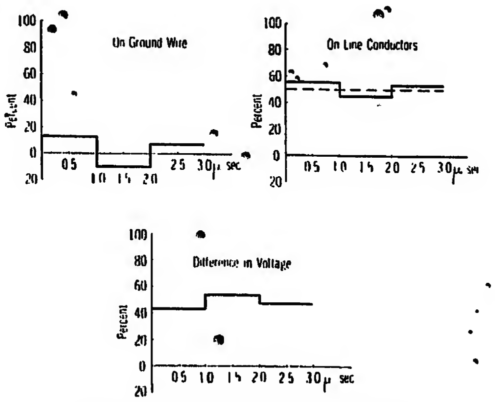

Fig. 19—Induced Voltages on Lines with Ground Wires

Voltages at the towers—based on equal induced voltages on ground and line wires ground resistance R = 20 ohms

of the whole industry; and now that the equipment is available, it is necessary only to work out the required organization of effort.

II. Theoretical Discussion of the Propagation of Lightning Surges

(This part of the paper is a rather complete mathematical treatment of the theory of traveling waves. Since it is not feasible to abridge a work of this nature, the reader is referred to the complete paper.)

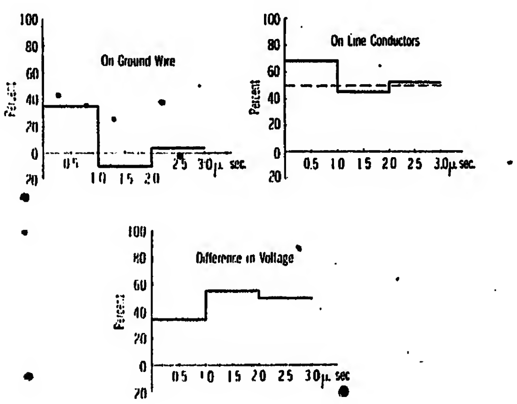

Fig. 20—Induced Voltages on Lines with Ground Wires

Voltages at the tower—based on equal induced voltages on ground and line wires ground resistance R = 80 ohms

III. The Effect of Ground Resistance of Overhead Ground Wire Protection of Transmission Lines

Overhead Ground Wires as Protection from Induced Waves. Equations (40) and (41) are of great importance for estimating the actual protection afforded by overhead ground wires to transmission lines when the value of the ground resistance is taken into account. We shall assume, a typical 220-kv. line with two ¾-in. ground wires, that the ground wires when at zero potential would reduce the potential on the transmission lines 50 per cent, and that the spans are 1000 ft. long which would give a wavelength of two microseconds. Then, Fig. 19 shows the potentials of ground wires, line wires, and difference of potential at the tower for ground resistance of 20 ohms.

Figs. 20 and 21 show the same voltage at the tower for resistances of 80 and 200 ohms respectively.

It will be noted that for an interval of two microseconds, the lower resistance gives the lower voltage

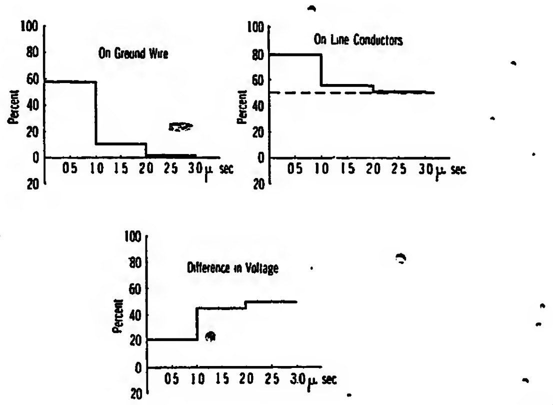

Fig. 21—Induced Voltages on Lines with Ground Wires

Voltages at the towers—based on equal induced voltages on ground and line wires ground resistance R = 200 ohms

with respect to ground. The curves of difference of potential between line conductor and ground wires, which is the same as the tower top, seems to favor the higher ground resistance. However, the tendency to arc over an insulator string depends not only on the potential to tower top but also on the potential to ground. Furthermore, the performance of ground wires during direct strokes is more important and the following discussion will show that for direct strokes, a low ground resistance is essential.

Overhead Ground-Wires as Protection against Direct Strokes. A second important practical application for these formulas is for the case of a direct stroke of lightning. We shall first take up the case where the lightning stroke hits the middle of the span.

The phenomenon of lightning discharge has been clarified to a large extent by the experiments of Torok[3]

3. J. J. Torok, *Surge Impulse Breakdown of Air*, Transactions, A. I. E. E., Vol. 47, No. 2, April 1928, p. 349.

in suppressed discharges between sphere-gaps. This phenomenon of suppressed discharge is very frequently observed in thunderstorms.

It is obvious that the intensity of a lightning stroke varies widely, depending upon the height and nature of the cloud, which determines the quantity of charge that can be dissipated in a single stroke. Many strokes never reach the earth, as frequently, due to insufficient energy to support and urge it forward, the progress of the streamer is stopped in mid-air. Others barely reach the earth and this with little energy. Still others, of course, are intense to varying degrees.

In the case of a direct stroke, when the ionized path is complete, there is propagated at once in the transmission line a steep wave-front surge, the crest value of which may last for two or more microseconds depending upon the potential of the cloud and how much of it is drained off over the discharge path.

When the flashover takes place, the cloud is discharged over the ionized path in the form of a surge traveling like any other traveling wave over a conducting path, and since the surge impedance of the path which it must follow decreases progressively as it approaches the earth, the crest of the propagated wave will decrease in potential, progressively, as it approaches earth, so that although the potential of the cloud may be something like 100 million volts, the propagated wave when it reaches a transmission line may not have a crest of more than four or 5 million volts. It may be assumed that when it strikes the transmission line, it has a surge impedance of the same order as that of three transmission line conductors in parallel and since it divides into two waves at this point, the crest value of each of these waves depends upon the surge impedances of the conductors struck and the lightning path, and the voltage of the lightning as it enters the line. This wave may enter the ground wires, the transmission lines, or both, and it will be reflected at the towers in both the earth and other conductors involved. There is no foundation for the opinion that all lightning strokes are so severe that they involve everything in the vicinity. It is likely that ground wires may be struck and conduct the energy away without involving the conductors. Evidence which indicates this has been obtained in klydonograph tests.

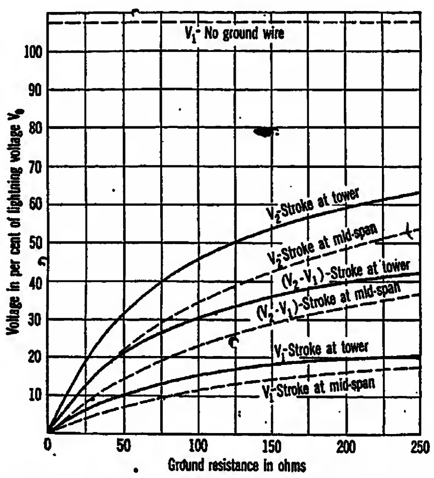

Fig. 24—Surge Voltage on Ground Wire V_2, on Line Wire V_1 and Difference of Voltage as a Function of Ground Resistance in Ohms in Terms of the Lightning Voltage at the Line V_0

Assuming the same typical 200-kv. line chosen above, the voltages at the tower were calculated in terms of the lightning voltage V_0 at the point of contact for various ground resistances and the results plotted in Fig. 24. In addition to curves for V_1 and V_2, a curve of $V_2 - V_1$, or the potential across the insulators, has been plotted. Although based on an assumed surge impedance of lightning path, Z_0 these curves illustrate the importance of low ground resistance in obtaining the highest measure of protection from ground wires against direct strokes. The value given for V_1 with no ground wires was calculated on the basis that the lightning stroke hit only one conductor. This illustrates that a large measure of protection is obtained from ground wires even with a high ground resistance.

Acknowledgment

In preparing this paper we had the assistance of several of our colleagues in the Engineering Department of the Westinghouse Company who took part in the various activities in connection with the lightning investigation.

ELECTRODEPOSITION AND CORROSION

The variety of articles to which the process of repair by electrodeposition can be applied has extended rapidly within recent years. This method of repair was employed extensively during the war, and has been since developed to a considerable degree in America. The experience gained by increased practise has certainly resulted in the product of a better repaired article. But it must be remembered that there can be no homogeneity in the metal of the repaired article. It is for the engineer to decide in each particular case whether the absence of homogeneity, with the consequent difference between physical and mechanical properties, is harmful to his purposes. As regards protection by electrodeposition, it should be remembered that, in so far as iron is concerned, zinc is the only really protective covering that is commercially applicable. Cadmium will protect iron almost as well as zinc, but the cost of cadmium restricts its use. Chromium does not protect iron from corrosion, though the deposit of chromium can be useful for other purposes.—*World Power.*

Abridgment of

Power Factor and Dielectric Constant in Viscous Dielectrics

BY DONALD W. KITCHIN*
Associate, A. I. E. E.

Synopsis.—This paper gives the results of a study of the peculiar variation with temperature and frequency of the dielectric constant and power factor of rosin, rosin oil, and castor oil. It includes data showing, at several frequencies, the relation of dielectric constant and power factor to the composition of vulcanized rubber.

Electrical double refraction in rosin at different frequencies and temperatures is discussed in relation to its behavior as a dielectric. It is shown that the viscosity is a decisive factor controlling both the electrical and optical behavior. The facts are important in themselves but it is possible to interpret them by a modern physical theory, the Debye[1] dipole theory, which it is believed has not hitherto been applied to commercial dielectrics. On this theory, the anomalous change of dielectric constant and power factor with temperature and frequency is attributed not to impurities or heterogeneity of structure but to molecules containing electric doublets which try to orient themselves in an electric field. The rotation of the dipole molecules in a viscous medium gives rise to frictional heat loss expressed as power factor, and also to a contribution to the dielectric constant which vanishes when the dipoles are prevented from responding by too great viscosity or too high frequency.

For the sake of intelligibility, first an outline of the dipole theory is presented and then the experimental results are discussed on the basis of that theory.

* * * * *

I. Introduction

The behavior of dielectrics in alternating fields has been the subject of considerable experimental and theoretical investigation. The purpose of this paper is to introduce the concept of the orientation of polar molecules as a basis of explanation of some aspects of dielectric behavior. The typical behavior is shown by rosin oil at one million cycles. (See Fig. 2, curves P_1 and D_1). It is readily seen that the observed temperature variation of dielectric constant and power factor cannot be explained by changes in density and leakage current. An attempt is made in this paper to explain this behavior by the Debye[1] dipole theory. Since the dipole theory of dielectrics may not be familiar to all who are interested in insulating materials an outline is given here. For a full presentation the treatise of Debye[1] should be consulted.

II. Molecular Behavior in Electric Fields

The electron theory of the dielectric constant is sufficiently familiar to require no discussion here other than to point out that the motion of the displacement electrons in following an alternating field may be considered to take place without lag and with no dissipation of energy.

1. Dipoles. There exist substances whose molecules are polarized even in the unstressed state due to their configuration. These molecules contain fixed electric doublets or dipoles which tend to turn them into line with an electric field. This tendency is opposed by the thermal motion, so that the effect of an ordinary field is a relatively small one which decreases with rising temperature.

For a dipole to respond to an electric field it is necessary for the molecule as a whole to turn, and any factor which affects the ease of turning controls the dielectric constant. The sudden and pronounced drop in ϵ when a dipole liquid freezes exemplifies this effect. If instead of freezing to a crystalline solid, the dipole liquid exhibits a great increase in viscosity on being cooled, the change in ϵ is gradual instead of sharp, and in addition, ϵ depends on the applied frequency, for while the dipoles may be so sluggish at a certain temperature that they cannot respond to a given high frequency, still they are able to follow a slower field and contribute to ϵ. The applied frequency therefore determines the region of viscosity, and consequently of temperature, where the drop in ϵ occurs. Rosin, rosin oil, castor oil, and glycerine (see Bock[5]) furnish good examples of this behavior.

2. Dipole Power Factor. The motion of the dipole molecules turning in a viscous environment gives rise to frictional losses, so that some of the energy of the field is dissipated in the form of heat. The magnitude of the resulting power factor is determined by two factors, namely, the amount of motion, of which the dielectric constant is a function, and the viscosity opposing the motion. At temperatures where the viscosity is low, the dipole power factor (so called to distinguish it from that due to leakage) is small. On the other hand, at viscosities practically great enough to prevent orientation, the power factor is again small. The maximum occurs in the intermediate region of temperature where the resultant of motion and high viscosity is greatest. This is the region where ϵ decreases with falling temperature.

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*Research Laboratory, Simplex Wire & Cable Co., Boston, Mass.

1. For all references see Bibliography.

Note: An English text "Polar Molecules" by Debye is announced by the Chemical Catalog Co.)

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Jan. 28-Feb. 1, 1929. Complete copies upon request.

III. Discussion of Experimental Results

Transil oil, tested at one million cycles between 70 deg. and 160 deg. fahr., showed negligible power factor. Light amber petrolatum showed a gradual decrease in power factor from 0.16 per cent at 74 deg. to 0.03 per cent at 210 deg. As expected the dielectric constant decreased

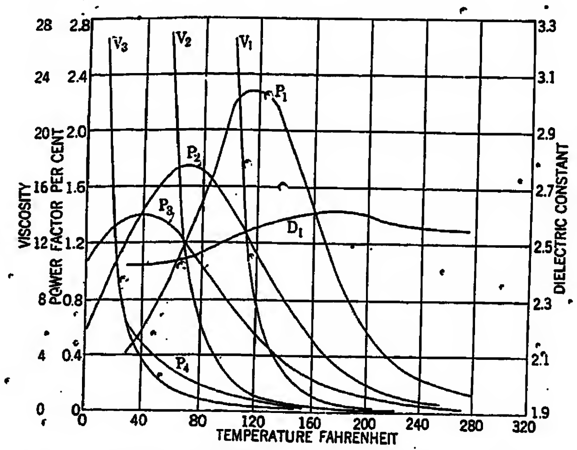

Fig. 2—Curves showing Effect of Dilution on Position of Power-Factor Maximum at 1 Million Cycles

D = dielectric constant
P = per cent power factor
V = viscosity Stormer—minutes per 100 turns
Subscripts refer to composition of mixtures:
1 100 per cent rosin oil (containing 50 per cent rosin)
2 80 per cent rosin oil 20 per cent Transil oil
3 50 per cent rosin oil 50 per cent Transil oil
4 20 per cent rosin oil 80 per cent Transil oil

with rising temperature. The peculiar behavior of a commercial rosin oil (50 per cent rosin, 50 per cent mineral oil) gave the first hint of an explanation of the anomalous change in power factor and dielectric constant. Inspection of the viscosity curve shows that the power factor maximum and the drop in ϵ occurs in a temperature region where the viscosity increase is very rapid. This suggests the idea that the power factor and a part of ϵ depend on some mode of motion which is greatly influenced by the viscosity of the medium. Dipole orientation discussed above readily accounts for this behavior.

1. *Effect of Dilution.* If the behavior was due to some chemical change in the dissolved rosin rather than to the effect of viscosity, dilution with a neutral oil (*i. e.*, one of negligible power factor) like Transil oil, should merely decrease the power factor without shifting the position of the maximum. If, on the other hand, the dipole explanation is correct, dilution with Transil oil to decrease the viscosity should shift both the power factor and dielectric constant maxima for constant frequency to lower temperatures. Fig. 2 shows that the curves for one million cycles shift in the predicted manner. It is readily seen that an enormous increase of viscosity is necessary to cut down the orientation sufficiently to cause a large power factor decrease. This is to be expected, since the great increase in dipole friction with rising viscosity partly counteracts the effect of diminishing orientation. The same reasoning explains the fact that the dielectric constant always starts to fall at lower viscosity, *i. e.*, higher temperature, than where the power factor maximum is reached.

Substitution of the more viscous Nujol for Transil oil in a 50 per cent mixture, with rosin oil shifted the position of the power factor maximum from 40 deg. to 55 deg. fahr. This is additional proof of the orientation theory, since the mere substitution of one neutral oil for another should have no chemical effect on the rosin content. Replacing the Transil oil with 50 per cent of heavy cylinder oil caused a still greater shift to 75 deg.

An interesting fact was shown by the behavior of a mix of 50 per cent rosin oil in 140 deg. paraffin. At 122 deg. it was apparently solid, yet the power factor curve showed no break. The explanation lies in the fact that the apparent consistency is not a true indication of the actual environment opposing the motion of the dipole molecules. In the stiff, salve-like mixture there is a distributed liquid component in which the dipoles turn freely until this liquid component becomes very viscous.

2. *Effect of Change of Frequency.* Fig. 3 shows the results at 60 cycles, 1 million, and 10 million cycles, obtained with Hercules Wood Rosin *F*. The

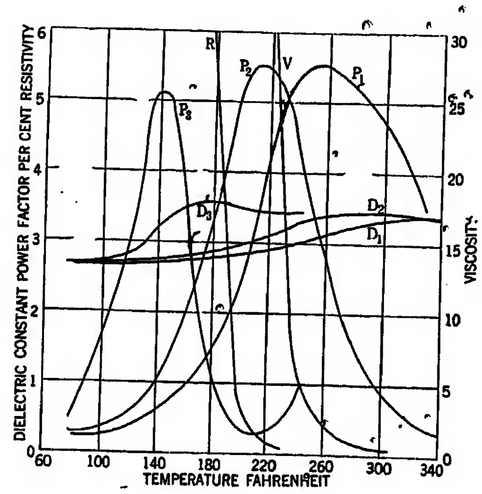

Fig. 3—Curves showing Behavior of Wood Rosin at Different Frequencies

V viscosity Stormer in minutes per 100 turns
R resistivity in ohms $\times 10^{12}$ per cu. cm.
P per cent power factor
D dielectric constant
Subscripts refer to frequency:
(1) 10 million cycles
(2) 1 million cycles
(3) 60 cycles

two higher frequency curves and the viscosity curve are plotted from data obtained by the writer; the data for the 60-cycle curve and the resistivity curve were kindly furnished by the Hercules Powder Co.

a. *Dielectric Constant of Rosin vs. Temperature and Frequency.* The course of the dielectric constant curves is in good agreement with the theory. At 80 deg. fahr.,

ϵ is the same for all three frequencies. This value $\epsilon = 2.68$ is due to the displacement electrons alone, as shown by the fact that the power factor has dropped to negligible values. The viscosity of the rosin at this point is so enormous that even the slighest dipole motion would give rise to high frictional losses, so that we may be sure that the contribution of dipole motion

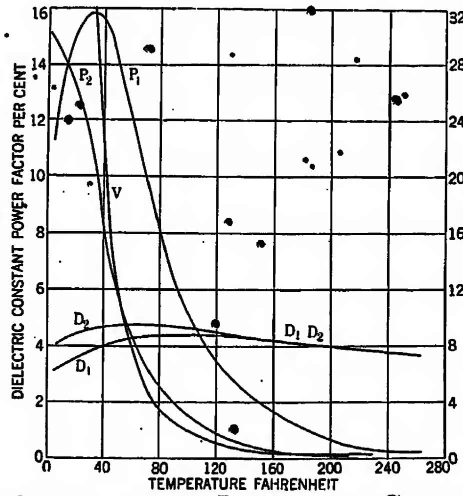

Fig. 4—Curves showing Behavior of Castor Oil at 2 Frequencies

V viscosity Stormer in minutes per 100 turns
P per cent power factor
D dielectric constant
Subscripts refer to frequency:
1 10.9 million cycles
2 1.415 million cycles

to ϵ is practically nil. Thus, when the dipoles are practically fixed—*e. g.*, down to 60 cycles,—ϵ is independent of frequency. On the other hand, the ϵ curves again converge on the high temperature side, because there the viscosity is very low, resulting in a characteristic frequency high compared to the three applied frequencies, and the dipole response is complete. At 180 deg. ϵ for 60 cycles reaches a maximum, while it is still low for the two radio frequencies. At this point, the dipoles respond fully to the 60-cycle field, but are too sluggish to follow the higher frequency fields. Above this temperature ϵ for 60 cycles drops because while the dipole response no longer increases, the density decreases. At 260 deg. and at about 310 deg., the dipole response to the 1 and 10 million cycle fields is complete.

b. Relation of Spacing and Width of Power Factor Curves. The comparative widths of the curves of power factor and dielectric constant (Fig. 3) and the way they are spaced with respect to temperature are good qualitative evidence of the correctness of the orientation theory. On the orientation theory the curves for equal multiples of frequency would be of equal width and spaced at equal temperature intervals, provided the viscosity changed exponentially with temperature But inspection of the viscosity curve for rosin shows that the viscosity change is more rapid.

The result is that the 60-cycle curve, being in a region of viscosity increase which is much more rapid than that in the higher temperature radio frequency region, is narrower than the 1 million-cycle curve, which in turn is narrower than the 10 million-cycle curve. Also, the 1 and 10 million-cycle curves are farther apart relative to the frequency difference than the 60-cycle and 1 million-cycle curves. The viscosities corresponding to 1 and 10 million-cycle power factor maxima are approximately in the ratio 10 to 1 as they should be.

c. Tests on Castor Oil. In order that all the tests might not be confined to rosin-containing materials, similar tests were made on a sample of refined castor oil. The curves are shown in Fig. 4. It will be noted that very high frequency is required to bring the power factor maximum above 0 deg. fahr.

3. Optical Evidence of Orientation. Some results of optical tests on rosin are included because of the additional support they give to the orientation theory. The work was done with Professor Hans Müller of the Massachusetts Institute of Technology, and is treated more fully in a joint paper.[14]

The phenomenon of electrical double refraction, called the Kerr[12] effect, is well known. Many materials become double refracting in a strong electrostatic field.

Non-dipole liquids show some Kerr effect, but polar liquids show it much more strongly. Since this effect depends upon dipole orientation, the time required for

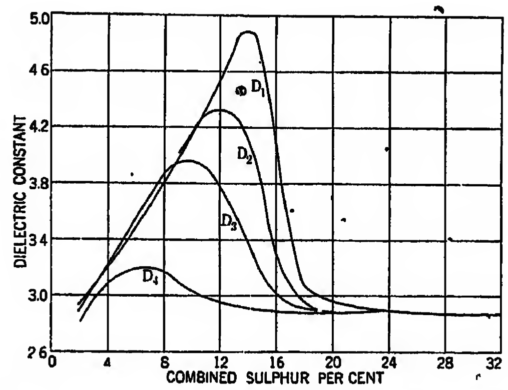

Fig. 5—Curves showing Dielectric Constant *vs.* Per Cent Combined Sulphur at 4 Frequencies

Subscripts refer to frequency:
1 0 cycles, *i. e.*, static stress
2 60 cycles
3 1000 cycles
4 380,000 cycles

the effect to disappear after sudden discharge should equal the relaxation time already defined for electrical polarization. Then, by reasoning similar to that which applies to the change of dielectric constant, the effect should fail to appear in an alternating field of frequency too high for the dipoles to follow. This prediction was confirmed by the behavior of rosin. At room temperature, solid rosin showed a good Kerr effect with a static field of 10,000 volts, but none whatever with a 60-cycle field even though the stress was increased to 75,000 volts.

The sudden discharge was produced by shorting the cell. A very long relaxation time for the optical effect was noted at room temperature. After discharge, it took least 30 seconds for the image of the slit to disappear. The threshold temperature for the appearance of the effect at 60 cycles was found to be about 100 deg. The difficulties of observation precluded an accurate determination of the threshold temperature at 1.5 million cycles, but the Kerr effect could be observed unmistakably above 240 deg. which is in approximately the correct region. Thus, the optical behavior of rosin at different applied frequencies gives strong additional support to the orientation theory advanced to explain anomalous power factor and dielectric constant changes.

4. *Electrical Behavior of Rubber-Sulfur Compounds.* Electrical tests at various frequencies on samples of vulcanized rubber containing different amounts of combined sulphur show very interesting features which may be related to the dipole theory.

Figs. 5 and 6 show that the positions of the maxima

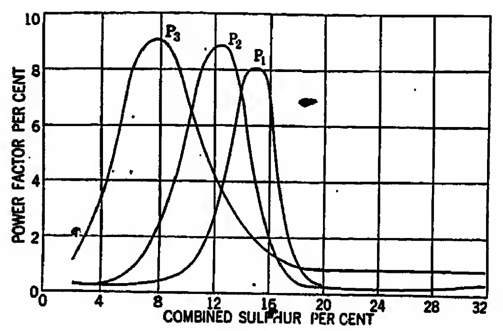

Fig. 6—Curves showing Power Factor *vs.* Per Cent Combined Sulphur at 3 Frequencies

Subscripts refer to frequency:
1 60 cycles
2 1000 cycles
3 380,000 cycles

can be shifted over a wide range of composition by changing the test frequency. The application of the orientation hypothesis to rubber is only tentative and considerable critical experimental work would be needed to place it on as firm a basis as in the case of viscous liquids.

Conclusions

1. The peculiar temperature variation of dielectric constant and power factor at different frequencies of rosin, rosin oil, and castor oil, and the anomalous change in electric double refraction of rosin have been shown to be functions of the viscosity.

2. The influence of viscosity on both the electrical and optical properties has been explained on the Debye theory of dipole orientation.

3. The electrical behavior of vulcanized rubber samples of various compositions suggests the presence of dipole molecules.

4. Very accurate measurements on viscous, dipole materials of high purity would be of great value in checking and extending the theory.

The results given in this paper are believed to be of value both to electrical engineers and to physicists. It is hoped that they will help to interest practical students of dielectrics in a physical theory which hitherto has been tested for the most part at frequencies and on materials remote from practical purposes.

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ENGINEERING SOCIETIES EMPLOYMENT SERVICE

EXCERPTS FROM LETTERS OF APPRECIATION

February 18, 1928.

I am enclosing herewith a check for $49.50 as a contribution to the Employment Service for its use by me in securing my present position. I hope that this may show to some extent my appreciation for the excellent service it has rendered me.

February 10, 1928.

The service rendered by the Bureau is excellent, and I heartily thank you for the assistance you gave me in obtaining the position at a time when general business conditions were very slack.

December 1, 1928.

We wish to express our appreciation for the helpful cooperation of the Engineering Societies Employment Service and thank you for your personal interest.

(signed) Plant Manager

November 10, 1928.

We wish to express our appreciation of your cooperation in securing the services of this engineer, as he and several other men interviewed, turned out to be the very highest caliber and we hope and expect to use your service to a larger extent in the future.

July 1, 1928.

I might say that I have been very much impressed by the excellent service rendered by your office, and a contribution will be forthcoming very shortly.

Abridgment of

No-Load Induction Motor Core Losses

BY T. SPOONER[1]
Member, A. I. E. E.

and

C. W. KINCAID[1]
Associate, A. I. E. E.

Synopsis.—A detailed method of calculating the no-load core losses of induction motors is presented, whereby each loss component is estimated separately. There is included a discussion of extra losses due to imperfection in workmanship. Calculated and test results on a few commercial machines are given as an indication of the reliability of this method.

IN general, the simplest and most reliable method of predicting the core losses in a rotating machine of new design is to estimate them from the test results on machines of similar type. This is the method ordinarily used by experienced designers. In some cases, however, this procedure is not adequate. For instance, if in a certain type of machine the core losses are higher than anticipated, a more detailed analysis is necessary, or if a machine is proposed which has certain radically different features from any existing machine, a calculation of losses based on fundamentals is essential if these losses are to be properly estimated. It is our purpose here to consider all of the important factors which produce no-load core losses in induction motors and similar types of apparatus and to give a method of calculating these losses.

TYPES OF LOSS

This discussion will be confined to induction motors, but it will be obvious that the methods can be applied to other types of machines in which both the stator and rotor are slotted and in which the air-gap flux has approximately a sine-wave distribution.

For the purpose of calculation, induction motor losses will be segregated into the following components:

1. Fundamental frequency losses.
   a. Stator core
   b. Stator tooth
2. Pulsation losses.
   a. Surface (stator and rotor)
   b. Tooth pulsation (stator and rotor)
   c. Copper eddy (stator and rotor)
3. Illegitimate losses.

The fundamental frequency losses are those due to the hysteresis and eddy-current losses in the core material corresponding to the applied frequency, and are assumed to be the same as would occur under alternating flux as in a transformer core for the same maximum induction. This assumption may be open to question so far as the core flux is concerned, since this flux has an elliptical, rather than an alternating variation but the simpler assumption with corrections, if necessary, for the elliptical field seems to give satisfactory results. It is assumed that the frequency of the main flux in the rotor is so low that the losses are negligible.

The pulsation losses consist first of the surface losses which are those hysteresis and eddy losses occurring just below the surface of the tooth tops due to the passage of the slots of the other member and are practically the same as the well-known pole-face losses.

The tooth pulsation losses are those caused by the high-frequency pulsations of flux extending the whole length of the teeth and a little way into the core due to the reluctance changes in the air-gap as the slots of one member pass the teeth of the other. The distinction between surface and tooth pulsation losses is somewhat arbitrary but seems to work fairly well.

The no-load copper eddy-current losses are not, of course, really core losses, but appear as such by the ordinary methods of test. They are due to the high-frequency slot-leakage fluxes as the result of the momentary changes in the saturation of the teeth. They have both tangential and radial components.

The illegitimate losses are those caused by punching strains in the tooth iron, short-circuited laminations due to burrs and slot filing, bending strains in the iron sheets, and finally to leakage fluxes into the frames, end-bells, and other solid members.

FUNDAMENTAL-FREQUENCY STATOR CORE LOSSES

The fundamental frequency losses in the stator core are to be calculated in the usual way from loss curves on the particular type of material to be used in the machine if the ratio of inside to outside radius of core is large or if there is a considerable number of poles corrections to be made for non-uniformity of flux according to the method described by Alger and Eksergian.[2]

FUNDAMENTAL FREQUENCY STATOR TOOTH LOSSES

The stator teeth of an induction motor are subjected to approximately a sine-wave variation of fundamental frequency flux on which generally is superposed a high frequency ripple corresponding to the number of slots in the rotor. It has often been assumed that these high-frequency pulsations tend to reduce the fundamental frequency hysteresis losses. It has been shown,[3]

1. Both of Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Presented at Winter Convention of the A. I. E. E., New York, N. Y., Jan. 28-Feb. 1, 1929. Complete copies upon request.

2. *Induction Motor Core Losses*, P. L. Alger and R. Eksergian, JL. A. I. E. E., October 1920, p. 906.

however, that this is not the case and that the fundamental frequency hysteresis losses are proportional to the maximum flux density, whether or not the high-frequency pulsations are superposed.

Referring to Fig. 5, B is the maximum magnetic flux density in the teeth as ordinarily assumed and B_m is the actual maximum flux density. It is necessary, therefore, to calculate the magnitude of these high-

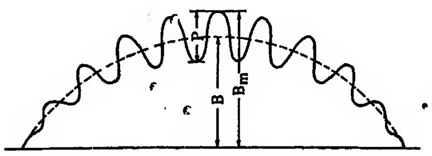

Fig. 5—Showing Tooth Flux Variations for Induction Motor

frequency flux pulsations in the teeth. This can be done by means of the formulas given in a previous A. I. E. E. paper.[4]

Surface Losses

The method of calculating surface losses has been described in the A. I. E. E. Transactions for 1924, p. 252.

Tooth Pulsation Losses

The method of calculating the magnitude of tooth pulsations has been given in a previous paper.[3] Corrections to the calculated pulsation P may be made according to Fig. 9, or assuming a straight line relation between induction and percentage pulsation P as effected by saturation the following formula may be used instead of Fig. 9.

$$P_S = P\left(1.6 - \frac{B}{100}\right) \qquad (9)$$

Fig. 9 and formula (9) are based on theoretical considerations only. Experimental results on actual machines seem to indicate that the following formula more nearly fits the facts for large induction motors.

$$P_S = P\left(1.3 - \frac{B}{165}\right) \qquad (10)$$

These corrections to P are based upon the assumption that the losses vary as the square of the pulsation amplitude. Of course the effect of saturation increases as the pulsations follow up along the fundamental flux curve toward the maximum value. These saturation effects have been integrated for the whole fundamental wave.

The variables for calculating pulsation losses are as follows: f_{st} or f_{rt} as above, where f_{st}, for instance, corresponds to the number of stator teeth, but is used to calculate the rotor tooth pulsation losses.

B_m, the maximum tooth induction, which for the stator teeth may be taken as the same as used in the calculation of the fundamental frequency tooth losses, or, more accurately, should be recalculated using curve 9 or formula (9) or (10). In the latter case:

$$B_m = B\left(1 + \frac{P_S}{200}\right) \qquad (11)$$

where B is the net tooth induction 1/3 from the narrowest section, P_S is the percentage pulsation as corrected for saturation.

$P\,B_m$ the product of B_m and P_S. The tooth pulsation losses for a wound rotor per net, cu. in. of core material are:

$$W_{rtf} = \underset{\text{(Hysteresis)}}{(10^{-3} f_{st} K_{Bm} K_P)} + \underset{\text{(Eddy)}}{(K_{PBm} K_{fst})} \text{ watts} \qquad (12)$$

The K factors are obtained from Fig. 10, K_{Bm} corresponds to the rotor tooth B_m as obtained from formula (11). K_P is the rotor pulsation constant corresponding to the percentage pulsation as corrected for saturation.

The hysteresis component of this formula was obtained from a fundamental study of the losses of displaced hysteresis loops. The eddy-current component was obtained by many tests on an experimental machine supplied with various slot combinations.

The stator tooth pulsation losses are calculated as follows when they are appreciable:

$$W_{stf} = (10^{-3} f_{rt} K_{Bm} K_P) + (K_{PBm} K_{frt}) \text{ watts} \qquad (13)$$

If the machine has a squirrel-cage rotor instead of a

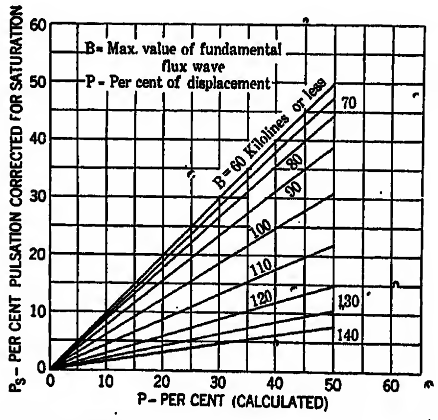

Fig. 9—Tooth-Saturation Correction Curves for Calculating Pulsation Losses

wound rotor, the conditions are different. In this case, due to the short-circuited turns around the teeth no very appreciable high-frequency flux can flow. Thus the tooth-frequency losses in the rotor teeth will be negligible. As pointed out by Alger and Weichsel[5] some years ago, however, the high-frequency currents which flow in the rotor bars produce a corresponding m. m. f. which acts on the stator teeth to produce high-frequency pulsations in these teeth which may be responsible for very considerable losses.

The magnitude of the stator tooth pulsations as a

3. "Effect of Superposed Alternating Field on Apparent Magnetic Permeability and Hysteresis Loss," T. Spooner, *Phys. Rev.*, Vol. 25, Sept. 2, 1925, page 527.

4. *Tooth Pulsations in Rotating Machines*, T. Spooner, A. I. E. E. Trans., Vol. 43, 1924, p. 252.

5. A. I. E. E. Trans., Vol. 44, 1925, p. 160.

result of the high-frequency rotor currents would be difficult to calculate accurately. Therefore, in the case of squirrel-cage motors, the expedient has been adopted of calculating the rotor tooth pulsation percentages as if there were no squirrel-cage windings, then assuming that these are the percentage pulsations which actually occur in the stator teeth due to the rotor high-frequency currents. The rotor tooth pulsations and therefore the pulsation losses are assumed negligible and the stator tooth pulsation losses calculated from formula (13) assuming P_s equal to the calculated rotor

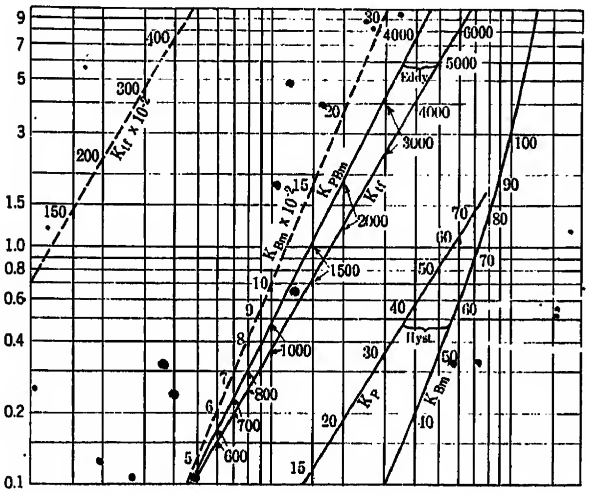

FIG. 10—CURVES FOR CALCULATING TOOTH PULSATION LOSSES

Note: All inductions and vol. are based on net section assuming a space factor of 90 per cent.

$W_{tf} = (10^{-3} f_t K_{B_m} K_P) + (K_{PB_m} K_{ft})$
W_{tf} = Tooth frequency loss in watts per cu. in.
f_t = Tooth frequency
K_{B_m} = Max. tooth induction factor (B_m is in kilolines per sq. in.)
K_P = Tooth pulsation factor (P is in per cent of B_m)
K_{PB_m} = Factor for % tooth pulsation and max. induction product
K_{ft} = Tooth frequency factor

$$f_t = \frac{\sim \times \text{no. of teeth}}{\text{pairs of poles}} = \frac{\text{rev. per min.} \times \text{no. of teeth}}{60}$$

For rotor f_t use no. of stator teeth
For stator f_t use no. of rotor teeth

tooth pulsation percentage. When the number of stator and rotor teeth is not very different, this is a fairly reliable assumption.

COPPER EDDY LOSSES

The cause and nature of these losses have been discussed in a previous paper.[6] They become of appreciable magnitude only at quite high tooth flux densities. These losses are caused by high-frequency slot-leakage fluxes which occur due to the saturation of the teeth. In general, since the conductors are small and the teeth are less saturated, the stator no-load copper eddy losses are negligible, but the rotor copper eddy losses are often appreciable both for squirrel-cage and wound-rotor induction motors.

6. *No-load Copper Eddy-Current Losses*, T. Spooner, A. I. E. E. TRANS., Vol. XLV, 1926, p. 231.

ILLEGITIMATE LOSSES

These losses have already been mentioned previously, and are losses in addition to those which would occur in annealed unsaturated cores with perfect insulation between laminations. Due to their variability they are difficult to estimate and should, so far as possible, be eliminated. They are one of the major causes of differences between calculated and test results.

One of the most common types of extra losses in rotating machines appears as the result of eddy currents caused by short-circuited laminations. Short-circuited laminations may be produced when types of construction are used such that the punchings are wedged onto dovetails or keyways, or are forced on the shaft. This connects together electrically the back edges of the laminations. Now if the teeth contain burrs or if the slots are filed, the laminations become short circuited and in this case there may result very considerably increased fundamental frequency core losses.

For motors with narrow teeth, there may be considerably increased losses due to punching strains. At an induction of 65 kilolines per sq. in., the losses are increased by an amount which can be calculated approximately by increasing the standard loss by a factor

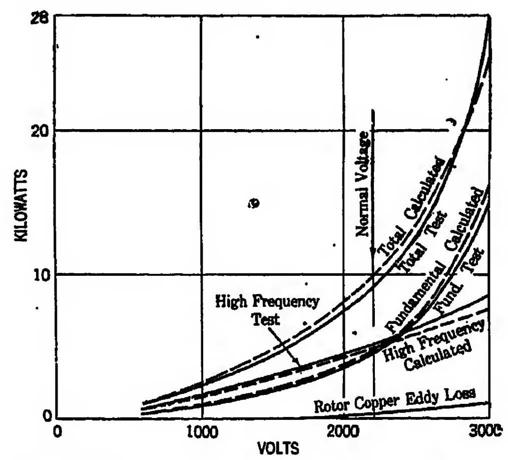

FIG. 12—WOUND ROTOR INDUCTION MOTOR

Comparison of calculated and test no-load core losses

equal to 14 divided by the mean tooth width in inches; namely:

$$W_{cor} = W_{std}\left(1 + \frac{0.14}{t}\right) \qquad (16)$$

At 100 kilolines the correction is perhaps not over one-half this value and at very high flux densities it is very small. If the stampings are annealed after punching there is no such correction.

If the punchings are not flat, bending strains may appear, increasing the losses at medium inductions. Above 100 kilolines there would be very little effect due to this cause.

If a motor is operated at very high core inductions leakage flux into the frames, end-bells, and other solid

members may cause the losses to go up very rapidly with voltage. In a properly designed machine operated at normal voltage this should be a small factor.

Experimental Methods of Separating Losses

The several different kinds of loss which must be considered to obtain the total have been described and

TABLE I
WOUND-ROTOR INDUCTION MOTORS
COMPARISON OF TESTED LINE FREQUENCY AND SLOT FREQUENCY LOSSES TO CALCULATED VALUES

	Per cent normal voltage	Line-freq. loss		High-freq. loss		Total loss	
		Test	Calc.	Test	Calc.	Test	Calc.
60-cycle...	56.8	1.00	1.36	2.20	2.33	3.20	3.69
12-pole....	79.5	2.10	2.32	3.70	3.55	5.80	5.87
	102.2	4.35	4.83	5.35	5.38	9.70	10.21
	125.0	9.80	9.90	7.40	7.20	17.20	17.10
		0.50	0.50	1.05	0.86	1.55	1.36
60-cycle...	56.8	0.96	1.06	1.94	1.98	2.90	3.04
16-pole....	79.5	1.98	1.97	2.82	3.20	4.80	5.17
	102.2	3.53	3.35	3.57	4.38	7.10	7.73
	125.0	6.03	6.41	4.17	5.83	10.20	12.24
		2.06	2.11	1.65	3.60	3.71	5.71
60-cycle...	56.8	4.67	4.55	6.13	8.35	10.90	12.90
24-pole....	79.5	8.67	8.70	11.63	13.18	20.30	21.89
	102.2	14.65	14.80	16.35	18.55	31.00	33.36
	113.7	19.55	20.15	19.85	21.59	39.40	41.74
	45.5	1.40	1.14	1.50	1.33	2.90	2.47
25-cycle...	60.6	2.31	1.82	2.50	2.11	3.81	3.93
10-pole....	75.8	3.40	2.75	3.50	3.00	6.90	5.75
	90.9	4.80	4.05	4.60	4.06	9.40	8.11
	106.0	7.00	6.21	5.70	5.18	12.70	11.39
	121.1	11.10	10.50	6.60	6.89	17.70	17.39

Checks on other machines, which were not specially tested, show the same general agreement in the total losses.

TABLE III
SQUIRREL-CAGE INDUCTION MOTORS
COMPARISON OF TESTED AND CALCULATED CORE LOSSES AT NORMAL VOLTAGE

Hp.	Freq.	Line freq. loss		High freq. loss		Total loss	
		Test	Calc.	Test	Calc.	Test	Calc.
250	60	1.98	1.87	1.72	1.22	3.70	3.09
500	60	6.04	6.02	3.93	3.14	9.97	9.16
175	40	1.08	1.07	0.95	0.64	2.08	1.71
125	40	0.82	1.15	1.30	1.27	2.12	2.42
225	40	1.83	1.96	2.09	1.53	3.92	3.49

it would be very convenient if each one of these several losses could be tested alone or separated from the others. This ideal will hardly be realized, but tests which give a separation of losses with respect to the frequency which causes them can be made.

One method which is applicable only to wound rotor motors was described by R. Richter in the *Elektrotech. Zeitsch.*, January 6, 1921.

This is the method that has been used in separating the losses in some of the motors shown in the curves.

Another method which is applicable to all types of machines is described by Messrs. Alger and Eksergian.[7] The fundamental idea is covered by their statement: "It is a general principle that whenever any cyclic variations in the permeance of a magnetic circuit are caused by the relative movement of parts of the circuit all the losses caused by this variation are supplied by the mechanical agency causing the motion."

Applied to the induction motor, this means that the tooth frequency losses are supplied by torque in the rotor. Now, the rotor can only receive power by running slower than the rotating field, *i. e.*, slipping, and by hysteresis loss in the rotor core and teeth. The slip can be measured very accurately by several means so that this portion of the rotor torque is known, but the hysteresis losses in the rotor core and teeth must be calculated. The hysteresis loss effect is as though it were at line frequency.

Another method requiring a driving motor and also accurate meter readings makes use of the step in the stator loss curve which occurs when the rotor is driven through synchronism. This has been described by Messrs. Alger and Eksergian[8] and by Messrs. Spooner and Kinnard.[9]

TABLE II
WOUND-ROTOR INDUCTION MOTORS
COMPARISON OF TESTED AND CALCULATED TOTAL LOSS VALUES

Per cent normal volts	60 cycles 10 poles		25 cycles 4 poles		25 cycles 8 poles		25 cycles 10 poles		25 cycles 34 poles	
	Test	Calc.	Test	Calc.	Test	Calc.	Test	Calc.	Test	Calc.
34.1	2.87	3.50	1.03	12.2	4.8	5.6				
45.5	4.89	5.46	1.68	20.2	11.8	9.9			7.4	6.7
56.8	6.69	7.22	2.87	30.8	16.8	16.1	68.0	50.4	15.1	13.4
68.2	9.55	10.36	4.16	45.3	28.4	26.0	88.6	86.2	24.6	21.7
79.5	12.70	13.36	6.22	61.4	38.0	38.1	137.0	141.	34.9	31.9
91.0	16.58	16.64	8.00	80.6	49.5	49.7	175.0	185.	46.3	41.4
100.0	20.26	19.85	10.66	10.60	63.8	64.2	204.0	222.	53.8	52.8
113.7	25.40	26.70	12.35	12.33	81.2	83.9	258.0	272.	57.9	59.6
125.0	32.00	32.46	14.10	14.67	99.0	98.2	345.0	342.	68.1	75.3

This method may be used on wound-rotor motors but on squirrel-cage motors the torque is so large that it is very hard to get satisfactory readings unless the frequency and speed are very accurately controlled.

Test Results

Several large wound-rotor motors have been tested according to the first method for loss separation and the losses have been compared with the losses calculated by the above described methods. The curve for

7. Alger and Eksergian, *loc. cit.*
8. Alger and Eksergian, *loc. cit.*
9. *Surface Iron Losses with Reference to Laminated Materials*, A. I. E. E. Trans., Vol. XLXXX, 1924, p. 252.

the line-frequency losses was obtained from one of the tested machines and checks well with the loss curve for the grade of iron used. Table I shows the fundamental and the pulsation-frequency losses calculated separately. Table II gives data for other machines without separation of losses. Fig. 12 shows the results graphically for one of these machines.

In Table III are presented some data on squirrel-cage motors. These checks are not as good as for the wound-rotor machines partly because of the greater difficulties of test. These results were obtained about three years ago. The calculated pulsation losses are probably low because no account was taken of copper eddy-current losses.

Conclusions

The above described method of calculating no-load induction-motor core losses appears to be rather tedious and complicated and as compared with the older empirical methods this is the case. However, by the use of a suitably prepared schedule the time may be greatly shortened. The time for such a calculation, provided all of the factors which have to be calculated for other purposes are available, is from 30 to 40 min. This is not excessive when dealing with a radically new design or with a type of machine which has given trouble due to high losses. It is hoped that this paper will stimulate discussion and will bring forth other methods for making these detailed calculations.

Abridgment of

The Predominating Influence of Moisture and Electrolytic Material Upon Textiles as Insulators

BY R. R. WILLIAMS[1] and E. J. MURPHY[1]

Non-member Non-member

Synopsis.—The insulating qualities of textiles vary with the amount of moisture present in them from hour to hour and are also strongly influenced by the amount of electrolytic material (salts, etc.) which the textiles contain. Electrolytic material may be washed out producing a commercially realizable increase in insulation resistance of the order of 50 times the original value.

The resistance of the animal fibers, silk and wool, is far greater for a given moisture content than that of cotton or of cellulose acetate, a derivative of cotton. It appears probable that the distribution of water as well as the quantity is important and that the two classes of fibers are characterized by different space patterns according to which the water is distributed. It is suggested that the space distribution patterns are associated with the colloidal structures of the materials and in turn with their chemical classification as proteins and celluloses respectively. Cellulose acetate absorbs little water as compared with cotton and is correspondingly superior electrically. However its resistance varies with moisture content in the sam way as that of cotton.

In spite of the great diversity of materials used for insulating purposes it is to a great extent absorbed water which determines their quality as insulators. Not only the amount of moisture but also its distribution is important, as is evident from the great variation in effect of a given increment of absorbed water upon the resistance of different materials such as cotton, silk, gutta percha, etc. Contamination of a variety of insulating materials with electrolytic impurities has also often been found responsible for poor insulating qualities. The textiles are peculiarly subject to the influence both of water and electrolytes.

Important contributions to the knowledge of the quantitative relations between the electrical properties of insulating materials and the moisture which they take up from the air have been made by Evershed,[4] Curtis,[5] Kujirai and Akahari,[6] Setoh and collaborators,[7] and other investigators. This paper is based upon an extended investigation of insulating materials particularly submarine insulation[2] and textiles[3] and is intended to emphasize the importance of moisture and electrolytic material on the behavior of textiles as insulators and to discuss briefly the relation of electrical characteristics to physical structure and chemical constitution, so far as possible with the available facts.

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1. Both of the Bell Telephone Laboratories, Inc., New York, N. Y.

2. Williams, R. R. and Kemp, A. R., *Jour. Frank. Inst.*, 35, (1927). Lowry, H. H. and Kohman, G. T., *Jour. Phys. Chem.* 31, 23 (1927).

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c. Murphy, E. J., "Electrical Conduction in Textiles. III. Anomalous Properties of Conduction in Textiles," *Jour. Phys. Chem.* 33, (1929).

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5. Curtis, Bur. of Standards, *Sci. Paper No.* 234 (1915).

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7. Setoh and Toriyama, *Sci. Papers, Inst. Phys. & Chem. Res.* (Tokyo) 3, pp. 285-323, 1926.

Presented at the Winter Convention of the A. I. E. E., Jan. 28-Feb. 1, 1929. Complete copies upon request.

General Characteristics of Textiles

It is obvious that the rapidity of response of textiles to atmospheric moisture is due first of all to their fibrousness which permits ready access to the interior of the mass through the large surfaces exposed.

Single fibers of cotton and silk have a resistance[8] which, considering the nature of the material, is surprisingly uniform for different fibers taken from the same material. Threads[9] of cotton and silk also have a uniform resistance. Even where the voltage is applied transversely to the long axis of the fibers, the resistance of different samples of the same material is fairly uniform. These facts suggest that interfiber contact resistances are only secondary or negligible in determining the resistance of a thread or other mass of fibers.

The form of the sample is not of predominating importance with reference to the insulation resistance of either cotton or silk, and a marked contrast exists except at very high humidity, between cotton and silk, in all forms of samples. Both these facts and other available data justify the inference that the dielectric properties of textiles are determined primarily by the composition or internal structure of the fibers, not by the twist of threads or the lay of servings.

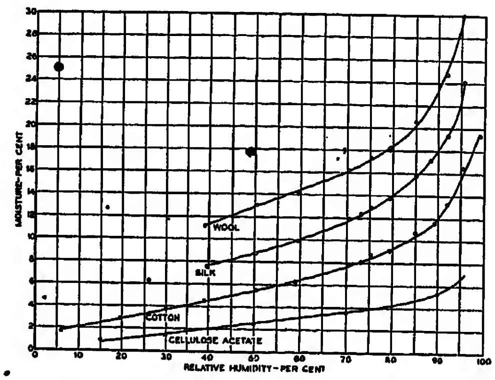

Fig. 1—Dependence of Moisture Content of Textiles upon Relative Humidity of Atmosphere with which they are Equilibrated

The moisture content of each sort of textile depends directly on the humidity of the atmosphere. Fig. 1 shows the moisture content of silk, wool, cotton, and cellulose acetate in equilibrium with air over considerable ranges of relative humidity. The data for silk and wool were taken from a paper by Schloessing;[10] those for cotton are due to Urquhart and Williams;[11] while those for cellulose acetate represent the figures of Wilson and Fuwa.[12] It is sufficient for our present purpose to emphasize the orderly dependence of moisture content upon the relative humidity of the atmosphere without discussing secondary phenomena or the full significance of the curves.

The relation of electrical behavior of each textile to relative humidity is also very close. Fig. 2 shows the insulation resistance of each of the above fibers plotted against relative humidity over the upper part of the range of atmospheric humidities. It is not practicable to plot the resistance over the entire range of humidity directly in this way, on account of the wide range of insulation resistance values which are obtained. In

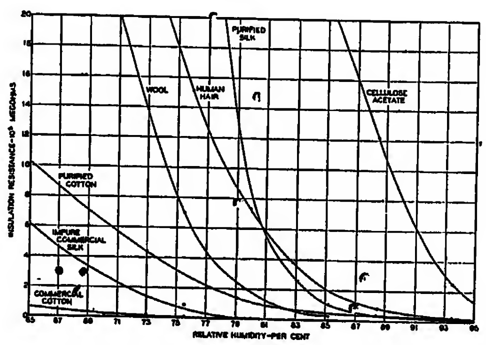

Fig. 2—Insulation Resistance of ½-In. Lengths of Textile Threads as Affected by Relative Humidity of Atmosphere

The purified cotton and purified silk had been submitted to a washing procedure to remove electrolytes. The impure silk was a commercial specimen representing somewhat more than usual contamination with electrolytes, while the commercial cotton is representative of its class

order to depict the fact that there is a consistent relationship throughout the range, we have plotted in Fig. 3 Log Insulation Resistance *vs.* Relative Humidity as far as values are at present available. When considered together, these three charts show that the insulation resistance of a textile depends on its moisture content, which in turn is a function of relative humidity. In other papers,[3] the electrical behavior of textiles in relation to relative humidity and moisture content is discussed more fully.

Perhaps the most significant evidence of the importance of electrolytic impurities in silk, wool, cotton, and to some extent other textiles, is the fact that their electrical characteristics can be greatly improved by thorough washing with water though without altering qualitatively the general nature of the electro-conducting phenomena which characterize them. Fig. 2 illustrates the result of washing upon the insulation resistance of cotton and silk threads. The improvement in insulation resistance of cotton and silk upon washing ranges commonly from fifty to one hundred fold, under any of the commonly prevailing conditions of atmospheric temperature and humidity. This im-

8. The experimental procedure is described elsewhere.[3a]

9. Because of their uniformity, small samples of thread (½ in. lengths) have been used in this laboratory as a convenient means of comparing the insulating quality of cottons and other textiles.

10. Schloessing, Th., *Bul. Soc. Encour. Indust. Nat.* 8, 717 (1893); C. R. 116, 808, 1893. Text. World Record, Boston, Nov., 1908, p. 219.

11. Urquhart and Williams, *J. Textile Inst.* 15, 143, (1924).

12. Wilson, R. E. and Fuwa, Tyler, *Ind. & Eng. Chem.* 14, 913 (1922).

provement is accompanied by diminution of the ash content, in the case of cotton from about 1.0 per cent to 0.15 or 0.25 per cent. It produces only a slight reduction in the equilibrium moisture content of the cotton over the ordinary ranges of atmospheric humidity. Commercial silks are similarly affected by washing.

If the mineral contents of cottons which have undergone washing are compared quantitatively with the original contents a decrease is observable, particularly as to potash, but the calcium and magnesium contents are much less altered. Fairly complete removal of potash is apparently essential to good electrical characteristics, but improvement electrically has been attended in some cases by an actual increase in content of alkaline earths. This suggests that interchange of electrolytic impurities between the textile and the water is involved as well as actual removal of electrolytes by the water. Thus in general hard natural waters, *i. e.*, those containing calcium and magnesium salts, have proved as good or better than soft waters when used in economically small amounts. Very exhaustive extraction with distilled water gives excellent results, though not vastly superior to washing with very dilute solutions of alkaline earth salts. Sufficiently complete and accurate analyses of samples of textiles brought into equilibrium with washing liquids and of the kind and quantity of electrolytes in the corresponding liquids have yet to be made to determine the precise importance of the composition of the saline residues. Non-saline electrolytes have also to be considered. This matter requires extended study and the experimental data are reserved for future publication.

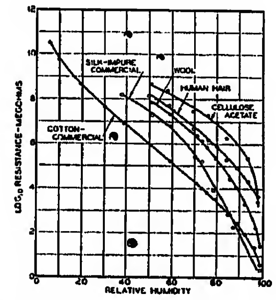

FIG. 3—LOG INSULATION RESISTANCE OF ½-IN. LENGTHS OF TEXTILE THREADS *vs.* RELATIVE HUMIDITY OF THE ATMOSPHERE

For description of samples see Fig. 2. For tabulated data see reference 3a

The commercial value of such treatments of insulating yarns have proved to be very substantial. The utilization of the products forms the subject matter of another paper from the Bell Laboratories.[13]

DISTINCTIVE CHARACTERISTICS OF EACH FIBER SPECIES

The several kinds of fibers exhibit a number of curious contrasts in the relation of electrical behavior to hygroscopic properties, some of which at first glance appear contradictory. For convenience in discussion let us classify the commercial fibers into two main groups: (1) the animal fibers, and (2) the vegetable fibers, and a sub-group (2a), the cellulose ester fibers of which the so-called cellulose acetate silk is the sole representative of commercial importance at present. It will be seen by reference to Fig. 1 that over the entire range of relative humidity the animal fibers, silk and wool, absorb more water than the natural vegetable fibers. This is true whether we deal with fibers in their natural impure state or after a washing process which has been shown to improve greatly the electrical characteristics of both types of natural fibers. Cellulose acetate absorbs less water at any given humidity than either class of natural materials.

We have seen that for any given kind of fiber there is an orderly dependence of electrical properties upon the moisture content of the fiber and in turn upon the relative humidity of the atmosphere. The more water present in any given fiber the poorer are the electrical properties. If the amount of water in fibers were the sole determinant of electrical characteristics we would expect the animal fibers to be, at a given humidity, the poorer electrically of the classes enumerated above.

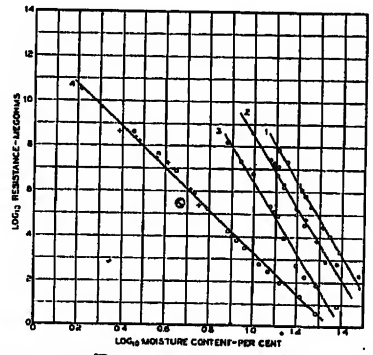

FIG. 4—INSULATION RESISTANCE AS A FUNCTION OF MOISTURE CONTENT OF TEXTILES

1. Wool yarn
2. Silk threads purified (○ sample 1 ● sample 2)
3. Silk threads impure
4. ○ Cotton threads, + cellulose acetate threads

But this is emphatically not the case. With respect to electrical properties, we find that the vegetable fibers are inferior to the more hygroscopic animal fibers and are also inferior to the least hygroscopic variety of commercial fiber, *viz.*, cellulose acetate. To make the existing contrast clear we have plotted in Fig. 4 for the several textiles, Log Insulation Resistance *vs.* Log Moisture Content. When so plotted the values for each kind of fiber fall approximately on straight lines throughout the range of actual measurement. The relative position of the curves for animal fibers to the right and above that for cotton[14] means that the animal

13. Glenn and Wood, *This Journal* 48, 146, 1929.

14. The threads referred to are approximately, but not precisely, of the same size. This variable is by no means sufficient to account for the higher position of the animal fibers as compared with cotton.

fibers have the better insulating qualities in spite of higher hygroscopicity.

The slopes of these lines have an even greater significance for they indicate the relative sensitivity of the fibers to an increment of moisture. Since the slope for the animal fibers is greater, it is evident that the animal fibers are more sensitive electrically to moisture than cotton. Under a given set of conditions they are not only wetter than cotton, but are more sensitive to the effects of further increments of moisture and yet they have a higher insulation resistance.

In one respect alone can we say that cotton is preferable as an insulating material. It has the merit of being more nearly uniform in behavior under a variety of weather conditions. When the amount of moisture taken up from the surrounding atmosphere by silk or wool is doubled, the electrical leakage increases by a factor of 50,000 to 100,000, while that for cotton rises by a factor of only 600.

The position and slope of the values for cellulose acetate are of great interest as the curve coincides with that for cotton, indicating that moisture affects these two fibers in a very similar manner. The essential electrical difference between these two appears to be satisfactorily accounted for by the fact that cellulose acetate absorbs less water than cotton at any given relative humidity of the atmosphere. The conversion of cotton which is essentially cellulose into cellulose acetate by the process of acetylation, has, as could be predicted on chemical grounds, reduced its hygroscopicity but apparently has not modified its structure greatly. Cellulose acetate is therefore put in a subgroup rather than in an independent classification.

We are justified on chemical grounds in classifying the fibers in the same way which we have found to be convenient for discussion of their hygroscopic and electrical properties. How much importance should be attached to this correspondence between the chemical and electrical classifications cannot be determined at present. However, the correspondence seems suggestive and deserving of a brief discussion. The first class, that of animal fibers, has a common chemical nature in that they consist largely of proteins.

That their common protein character is responsible in some way for the properties of principal interest from the insulating standpoint is rendered the more probable by the close resemblance of silk and wool, as shown by the approximate parallelism of their curves in Fig. 4. This resemblance is shared in considerable measure by other hairs than wool.

The second class of fibers, coming from the vegetable world, are alike in being composed of cellulose, a substance like the protein in having a high molecular weight but unlike it in that its polar groups are hydroxyls which have a faintly acidic rather than amphoteric nature. These are the groups in cellulose with which water is likely to associate itself. Such data as are available concerning vegetable fibers other than cotton, notably linen, ramie, manila hemp, and wood pulp, indicate a strong resemblance not only chemically but hygroscopically and electrically.

The sub-class embracing only cellulose acetate as a commercial fiber is chemically more neutral and non-polar in type than other cellulose fibers, with which fact it is reasonable to associate its lower hygroscopicity and consequent better electrical characteristics. It is probable that cellulose nitrate and cellulose ethers will be found to fall in this class but artificial silks other than cellulose acetate absorb more water and appear on chemical grounds to be better classified with the cellulose fibers of natural vegetable origin.

The fact that the electrical characteristics of the two classes of fibers as affected by moisture appear to be specific properties of the substances involved suggests some highly regular distribution pattern of conducting water paths determined by the chemical or physical (colloidal) structure of the material. Such a regular pattern may involve only water condensed upon the surfaces of the elements of structure in such a way that the thickness of the film varies regularly from point to point through the material. Accumulation of water at thick points would have little electrical effect, while that in thin portions would be very significant. An alternative regular mode of distribution would involve water in part dispersed in solution or chemical combination within the units of structure of the material and in part in fairly uniform thin films on their surfaces, in which case the latter would have the major electrical consequence. While such a regular form of distribution seems preferable, it is perhaps not the only way of accounting for the electrical properties observed.

ARCING LINE CONNECTORS CAUSED INTERFERENCE

A baffling case of radio interference caused much distress to the citizens of Albert Lea, Minn., some time ago. The interference manifested itself as a continuous sound, obviously caused by a maintained arc. It was finally located by means of a portable set inside of a sleeve clamp connecting an aluminum to a copper conductor on a transmission line on the outskirts of the city. The hole in the connector for the reception of the aluminum conductor was lined with aluminum and the hole for the copper conductor was lined with copper. The man who installed the connector reversed it so that the contacts were between unlike, instead of like, metals. Corrosion occurred in the course of time, until finally an arcing contact was established. When the connector was replaced the interference ceased, thus terminating a prolific source of radio complaints.—*Electrical World.*

Abridgment of

Southeastern Power & Light System

Interesting Features of Development and Operation

BY A. T. HUTCHINS*

Non-member

Synopsis.—The rapid growth of the Southeastern Power & Light system is noted. Long forecasts, operating methods and new plant designs are discussed briefly.

AMONG the larger groups of public utilities, the Southeastern Power & Light Company is scarcely more than an infant. Organized in 1924, the last important changes in its structure were made only a few months past. The generation reported for 1925, 1926, and 1927 were approximately 1.2, 2.0, and 2.2 billion kw-hr. The increase in 1926 over 1925 was largely due to the addition of the Georgia companies.

ADVANTAGES FROM INTERCONNECTION

During its short life there have been realized for its subsidiaries many important benefits from physical interconnection and coordinated load dispatching. Improvement in economy of operation has been secured, first, by carrying the load of small communities over lines from sources of low cost of generation, and second, by coordinated use of hydro plants of the storage and run-of-river type and of steam plants, and by construction of new plants in units of large capacity. Improved service has been secured through better interconnections and increased number of sources of power. The advantage to the load districts resulting from service from a number of lines from different directions is easily appreciated when it is noted that severe meteorological disturbances do not often occur simultaneously over a wide area. Usually only a narrow zone is affected by wind storms of such severity as to disable a circuit so that it cannot be reclosed after tripping. Similarly storms accompanied by severe lightning usually travel over the country so that these disturbances are not simultaneous over wide areas. In general, the larger loads are supplied by lines and plants of such capacity that service is maintained even if more than one line is out of service. These facts explain the great improvement secured by building lines supplying the same area along routes separated from each other.

SYSTEM PLANNING

Extensive surveys of load prospects in every section of the territory have been projected several years into the future. Although it is known that the best of such estimates will miss the final development the location of important water power sites is known, the extent of coal fields and coal qualities are fairly well known, and the major trunk lines for the system have already been built. With this foundation, a study of load densities for the various sections of the system, extending ten or twelve years into the future, is of value principally to prevent any construction which would not fit with good economy into the final set-up. This being secured, the procedure resolves itself into making definite plans to care for load conditions two years in advance.

In general, the hydraulic structures being built for this system have a relatively high factor of safety, due to the point of view of the engineers, and, no doubt, partly to the comparatively short history of stream flows resulting in a greater uncertainty as to maximum flow to be expected.

The design of Jordan Dam which is located about 18 mi. down stream from Mitchell Dam on the Coosa River makes use of a variation in forebay level and the buttress type of power house which may be of interest.

Descriptions of the Thurlow back-water suppressor installed at Mitchell Dam have been published.* It is only necessary to note that the use of the suppressor will maintain normal head on the plant with flows up to 170,000 cu. ft. per sec. at which flow the tail race is up about 15 ft.

The design at Jordan Dam takes advantage of this feature and raises the forebay level 7 ft. to compensate for tail-race rises at high flows.

The normal tail-race level at Mitchell Dam is at elevation 282 to 283. The spillway at Jordan is 1122 ft. long with 612 ft. open at elevation 283. The remainder is controlled by 17 gates whose crest is at elevation 290, each gate being 30 ft. long and 18 ft. deep.

With a stream flow of 52,000 cu. ft. per sec. approximately 17,000 cu. ft. per sec. may be used through the four 36,000-hp. wheels and 35,000 cu. ft. per sec. will flow through the open spillway section bringing the forebay level to the elevation 290 and actually increasing the head on the plant. It is expected that this seven-foot rise in the forebay level will compensate for

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Presented at the Regional Meeting of the Southern District No. 4 of the A. I. E. E., Atlanta, Ga., Oct. 29-31, 1928. Complete copies upon request.

*"New Developments in Hydroelectric Power Plant Designs," by J. A. Sirnit, Amer. Soc. Mech. Eng. *Trans.*, Vol. 44, p. 361-'22.

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the tail race rise up to stream flows of 75,000 cu. ft. per sec.

It is apparent that while 283 is the elevation for the tail race at Mitchell Dam and also the open spillway at Jordan, the backwater suppressor at Mitchell Dam will maintain full head against the rise of seven feet.

In addition to this, the open spillway avoids the necessity for operating spillway gates except for flows above 52,000 cu. ft. per sec.

A general idea of the buttress type power house is shown in Fig. 4. At each end of the building and between units, buttresses extend from the upstream face of the powerhouse to the solid masonry between draft tubes, thus carrying the greater part of the load on this section of the dam. Such design permits the location of units 40 ft. nearer the face of the dam, and shortens the penstocks by that distance.

Steam Plants

The use of either 600-lb. or 1200-lb. pressure of steam with reheat cycles and the combined cycle of mercury vapor and steam has had wide publicity and plants using these cycles are increasing in number with a possible trend to neglect 600-lb. pressure and step from 400-lb. to 800-lb. or 1200-lb. pressure.

The most recent unit under construction on this system is designed to use 400-lb. pressure at the turbine throttle, a steam temperature of 725 deg. fahr., and a net economy of the plant for a year's output of approximately 16,000 B. t. u. per kw-hr. On account of high temperatures of circulating water at Gorgas, this unit was designed for best efficiency with 2-in. back pressure at the exhaust nozzle. Some of the essential features of this unit are as follows:

Turbo generator—60,000-kw., 90 per cent power factor, 13,800-volt, single-shaft, 1800-rev. per min., closed generator cooling system using raw water for cooling.

Turbine—three valves 17-stage with 4 bleed points for heating the feed water to 360 deg. fahr. at 52,000 kw. load and a B. t. u. rate chargeable to the turbine—11,350 B. t. u. per kw-hr. at that load.

The unit is built for a maximum load of 66,667 kw. at unity power factor. Steam will be supplied to this turbine from two boilers, each rated at 3040 hp. and equipped with pulverized fuel burners and fans of sufficient capacity to secure a maximum rating of 450,000 lb. per hr.

It was found that the increased capacity of the turbine and slight increase in efficiency more than compensated for the added cost of valves and fittings designed for 600-lb. pressure over those for 400-lb. pressure.

The use of air preheaters and a correspondingly high temperature of gases leaving the boiler surface with the high pressure used showed good economy in the use of the fourth bleed point for feed water heating. However, on account of crowding of piping and heaters and consequent difficulty in operation and maintenance, it is likely that the next unit will use only three bleed points for feed-water heating.

Lines and Tie-in Facilities

Lines are always designed for economy based on load and use factor but the necessity for carrying loads with one or more circuits out results in a system which is more or less flexible and which, under certain conditions, makes a maximum use of regulating equipment such as synchronous condensers or spare generators operated as condensers.

At this time 125,000-kv-a. capacity in synchronous condensers is installed at advantageous points on the system. One of these having a capacity of 15,000 kv-a., located at Lindale, Georgia, is equipped with a high-speed excitation system. A 90-mi. line from the U. S. Government plants on the Tennessee River to Gorgas, near Birmingham, has been in operation at 154 kv. for some time. A 133-mi. line from Martin Dam to the Atlanta district is spaced and insulated for the same voltage. Three of the newer hydro plants, the last of which will not be in service until next year, were designed for high-speed excitation.

In a system so extensive and having generating plants using stream flow varying so greatly from season to season or over a cycle of years the securing of high load factors on transmission lines is extremely difficult and increased losses, due to overloading under unusual conditions, must be accepted in place of the cost of additional copper and a lower use factor.

The combination of run-of-river and storage plants, served by the same lines, is, in general, advantageous, but extreme conditions arise under which it is not practicable to transmit with normal losses the output from these plants to the load.

Reports from individual plants show the details of operations. Steam-plant reports include a heat balance for the day's operation, and hydro plant reports show a record of water used, stored, or passed over the spillway. At the hydro plants records of the operation of the wheels at the gate opening used and the discharge through the spillway gates are employed to check the stream-flow gages. For some time there has been in progress a series of tests which will include one unit of each of the various sizes and manufacture. To date these tests have been of high value.

It is often possible to install at the time of testing a pair of piezometers in the penstock and scroll case so arranged that the differential may be determined by the use of a manometer and the values plotted in terms of water flow and thus be available for check runs at any later date.

It is found that a careful audit of stream flow and water use, especially for flows less than the capacity of the plant, is of real value in securing maximum output or maximum time operation at gate openings of high efficiency. This, of course, implies a nice cooperation between plant operators and load dispatchers.

Load Dispatching

The load dispatchers must be responsible for coordinating the entire system, not only for daily and weekly runs but they must follow through for an entire year or even a cycle of two or three years.

In general, the run-of-river hydro plants are operated on the base load whenever the stream flow approaches the capacity of the plant. During the dry weather such plants are operated on a daily or weekly cycle to secure the maximum output in hours of peak load. On the other hand, those hydro plants supplied from storage reservoirs will be operated on a schedule based on stream-flow variations for a year or even more, and effort is being made to have full reservoirs available for the dry season of each year, including a year of low stream flow. This will permit replacing some of the loss of capacity at the run-of-river hydro plants resulting from extremely low stream flow.

The steam generation will vary widely from a minimum during wet weather seasons, when run-of-river plants are carrying full load, to a maximum during periods of lowest stream flow.

Typical plant operation during a wet and a dry day in a year having ordinary seasonal stream flows is shown on Figs. 2 and 3.

Fig. 2 shows conditions in October of 1927 when the storage plants existing at that time were being used for a considerable output to supplement the run-of-river plants at which the stream flows were low during that month. The steam plants operated throughout the twenty-four hours of the day together with run-of-river energy purchased from the government at Muscle Shoals, which plant was available only on a basis of constant output. The other run-of-river power was blocked into the daily peak together with most of the output from the storage plants.

In a sharp contrast to this, Fig. 3 shows the daily load diagram for March of 1928 under conditions which may be termed normal in wet weather. Storage at this time was being built up, and the most efficient steam plants were being run for a half million kw-hr. daily, as shown, to carry the load with the output from the run-of-river hydro plants and a small output from the storage plants. Stream flow into storage above that used by the plants is plotted above the load curve.

The output from the storage hydro plants of the system in service in 1927, secured by a maximum draw-down was approximately 230,000,000 kw-hr.

The use of Upper and Lower Tallassee plants, the first finished in June 1928 and the latter to be put into service in 1929, will increase this output through the use of water stored at Martin Dam by approximately 130,000,000 kw-hr. so that the output from stored water in 1930 will heave nearly the same ratio to the total load at that time as shown in these load diagrams.

The maximum hourly load carried by the storage plants in 1927 is shown as 165,000 kw. with fairly long-hour use. Capacity available in 1930 will be double this amount with provision in the hydraulic structures for 80,000 kw. additional which may be installed when the proportion of steam generating capacity has greatly increased and the storage plants are pushed higher into the peak. The economy of such added capacity at

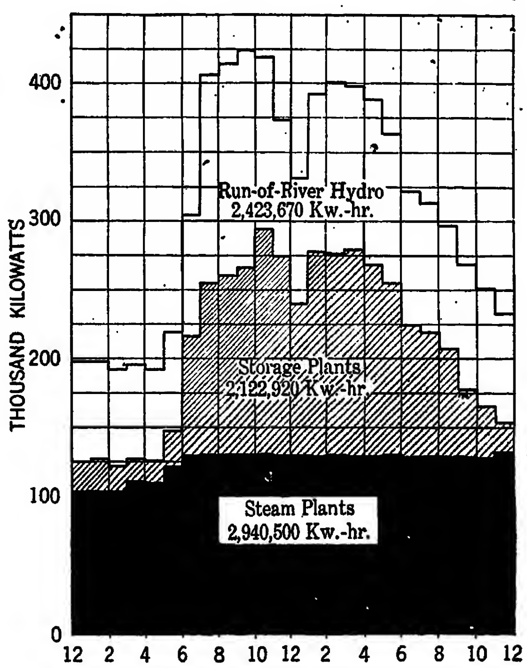

Fig. 2—Load Curve—Typical Day, Normal Dry Month

the hydro plants is based on a cost of construction of about 50 per cent of that for steam units.

This cost does not include the lines and tie-in facilities and therefore some advantage would be lost if the peak loads to be carried were served over new circuits at a greater distance in the case of hydro units than for steam units.

Seasonal Maintenance of Equipment

On a system where the only source of supply is from steam plants, there is necessarily provided sufficient capacity so that units may be available in turn as required for inspection. Practically all operating companies make it a practise to inspect the large turbines once every year. On such systems, it sometimes happens that the load demand approaches capacity so closely that the inspection must be made during

seasons of low demand, thus making all equipment available for operation during the year's peak.

In contrast with this, it is interesting to note the schedule of inspection and maintenance possible where the plants have a fairly definite seasonal requirement. On this system turbo-generator units at the steam plants are scheduled for inspection during the wet month of the year, which are included in January to June. During this time, besides the regular dismantling and inspection, any pre-scheduled major repairs are also undertaken. Similarly the work on the hydraulic units at the run of river plants is undertaken during the dry months when only a portion of the installed equipment is needed to use the entire stream flow.

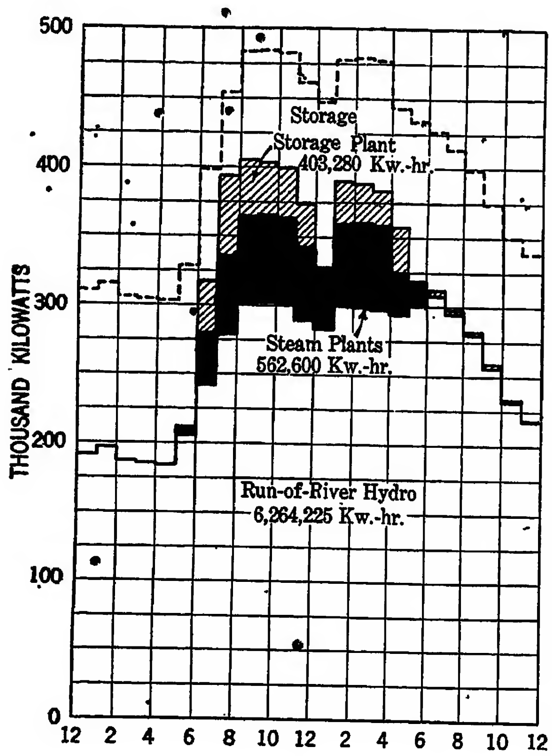

FIG. 3—LOAD CURVE—TYPICAL DAY, NORMAL WET MONTH

Repair of Wheels by Electric Welding

Very rapid pitting of cast iron runners at one of our plants brought about conditions calling for extensive repairs by welding. Cast steel inserts of considerable size were used and the metal of the wheel surrounding these was built up to normal thickness by electric welding.

The results of this work have emphasized to our operators that repairs should not be delayed in the hope that the pitting will cease as a natural course of events.

Besides such maintenance work, we find it necessary to overhaul completely the moving parts from the servo-motors to and including the wicket gates every twelve to fifteen years. This work includes the replacing of worn liners, bushings, rings, pins, welding up the shafts of wicket gates which may be worn, and, in general, bringing these parts of the machine practically to a new condition.

By carrying on maintenance as far as practicable during the season of low generation at the steam plants a further benefit is secured, namely, the reduction in labor turn-over and a more advantageous use of the force of men necessarily continuously employed at the steam plants.

Modern steam-electric units should be available for use 85 per cent of the time. With spare units available to permit inspection and repair, the factor of availability, when required, should approach 100 per cent. By means of scheduling inspection as outlined above, we have obtained a factor of availability, when required, of 99 per cent for three years, and of 99½ per cent for the year 1927.

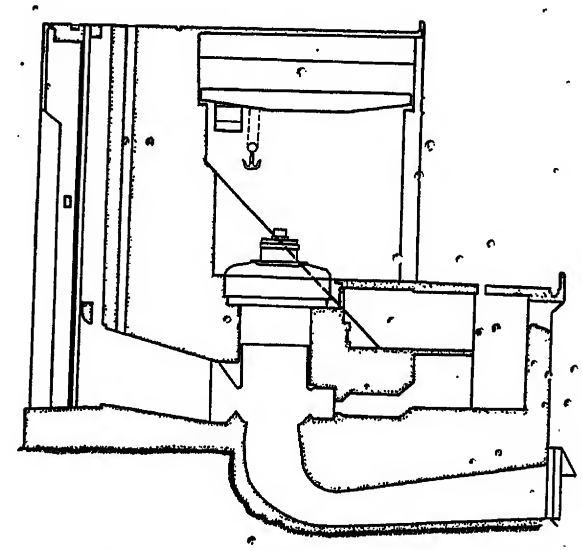

FIG. 4—JORDAN DAM POWER HOUSE

Transverse cross-section through center line of unit

Hydraulic Structures

Throughout the history of the subsidiary companies of the Southeastern Power & Light Company there has never been any necessity for repairs to hydraulic structures at any of the major plants.

In the foregoing paragraphs we have touched very briefly upon those features of system extension, operation, and maintenance which seem to us to present points of at least passing interest.

Abridgment of

Automatic Reclosing High-Speed Circuit Breaker

Feeder Equipment For D-C Railway Service

A. E. ANDERSON*

Associate, A. I. E. E.

Synopsis.—*High-speed circuit breakers have been used in both feeder and machine circuits of railway substations. It is the purpose of this paper to point out some of the advantages gained by placing this type of breaker in the feeder circuit and also to describe some of the more common types of feeder equipment using a well-known form of high-speed circuit breaker. A brief summary of the breaker characteristics is given, together with the results of short-circuit tests made on 600-volt reclosing feeders employing this type of breaker.*

The reclosing action is ordinarily obtained by means of a relay which, in conjunction with a load indicating resistor, measures the resistance of the external circuit. In order to permit feeder conditions to reach a stable value and particularly to enable all transient and counter e. m. f. effects to disappear before the reclosing devices are given control after the opening of the breaker, the action of this relay is purposely delayed. The latter effects usually disappear within a few seconds of the opening of the breaker on the usual type of railway circuits. In a majority of cases a time delay of 10 to 30 seconds (after the opening of the breaker) elapses before the reclosing devices are given the control of the breaker. After this time delay has expired and load conditions have reached the desired value, the circuit breaker is reclosed.

In some cases, especially for sectionalizing purposes, it has been found satisfactory to take the reclosing indication and control from the load side of the breaker. This feature requires that some other breaker undertake the reestablishment of voltage on the load circuit. By means of supervisory control the range of such equipment can be extended so as to pick up a dead section during abnormal operating conditions.

A majority of 3000-volt installations has been made in connection with main line electrification where the desired reclosing operation is a combination of load-indicating and load-limiting functions. Voltage increments on the load of too large a value may increase the tractive effort to such values as to cause wheel slippage of the locomotive, or snapping of draw-bars; consequently the load voltage is raised in graduated steps by progressively short-circuiting portions of load-limiting resistors placed in the feeder circuit.

* * * * *

CHARACTERISTICS OF THE HIGH-SPEED AIR CIRCUIT BREAKER

THE type of automatic reclosing equipment described in this paper makes use of a well-known magnetically-held high-speed air circuit breaker. A brief explanation of this type of circuit breaker, as illustrated in Fig. 1, may aid.

The breaker is a self-contained device. It is closed by means of a closing or reset coil which seats an armature against the pole faces of the holding magnet. During this operation, the auxiliary contacts move between the positions corresponding to the open and closed positions of the breaker, but the main contacts do not close until the closing or resetting mechanism is returning to the open position. Due to this function, which is obtained by a suitable system of levers, etc., the breaker is free to trip during the closing operation.

A set of springs is attached to the moving contact. These springs exert a certain amount of opening force when the breaker is held in the closed position.

The breaker may be opened in two ways; (a) by decreasing the holding coil current, or shunting flux from the holding armature; (b) by decreasing the holding coil current, a point is reached where the opening springs overpower the holding effect and the contacts consequently open. The breaker is tripped on overcurrent by means of a trip coil or bucking bar which is so placed in relation to the magnetic circuit as to shunt or transfer enough flux from the armature, thereby decreasing the holding effect and allowing the contacts to be opened by the opening springs.

The holding coil is connected in shunt with the source, which fixes the polarity of the holding flux. In order to shunt the flux set up in the armature by the holding coil, the current in the tripping circuit must flow in a certain direction. If it flows in an opposite direction it merely tends to increase the flux in the armature as already set up by the holding magnet. Due to this relation of the magnetic circuits, the tripping characteristic of the breaker may be said to be polarized, and in order to trip the breaker current, must flow in a given direction in the line.

ADVANTAGES OF PLACING THE HIGH-SPEED CIRCUIT BREAKER IN THE FEEDER

Fig. 2 shows a typical installation of high-speed circuit breakers as part of reclosing feeder equipments in an automatic substation. By placing these breakers in the feeder circuit it is possible to remove any suddenly applied overloads or faults without any serious effect on the remaining feeders supplied from the station. The feeder handles its own circuit conditions without reflecting them back to the machine, which might cause the insertion of steps of machine load limiting resistors, reduce the voltage on the remaining feeders, and consequently decrease the car speed.

If conditions warrant the use of a high-speed circuit breaker in the machine circuit, together with corresponding breakers in the feeder circuits, it is possible to

1. Switchboard Engg. Dept., General Electric Co., Philadelphia, Pa.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Jan. 28-Feb. 1, 1929. Complete copies upon request.

select the trip points and the discriminate so as to permit the feeder breaker to trip first.

There are conditions when the machines in an automatic substation are shut down; for example during light-load periods; but the feeder breakers are closed so

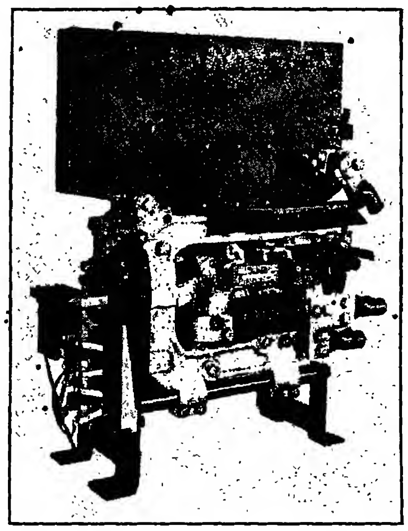

FIG. 1—600-VOLT D-C. 2000-AMPERE MAGNETICALLY-HELD HIGH-SPEED AIR CIRCUIT BREAKER

that the station bus becomes a tie point between the feeders, some of which may be feeding power into the bus and the balance feeding outwardly. All feeder breakers in this case are connected so as to trip only on outgoing current. This inherent polarized tripping characteristic of the breaker has been described above.

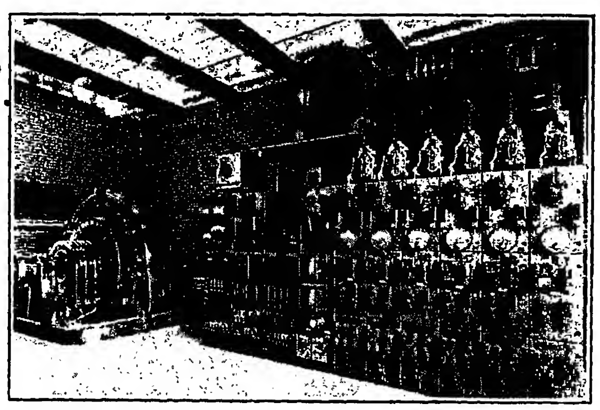

FIG. 2—AUTOMATIC RECLOSING HIGH-SPEED CIRCUIT BREAKER FEEDER EQUIPMENTS AS INSTALLED IN A 600-VOLT AUTOMATIC RAILWAY SUBSTATION

When a fault occurs on one of the feeders, only that particular feeder is tripped, since the remaining feeders are either carrying current below their trip points or else the current is flowing through their trip circuits in a reversed direction.

Other operating conditions may sometimes find two or more breakers in series (at different substations) with the fault current flowing through them in a direction to produce tripping. Due to the decreased voltage across the holding coil of the breaker nearest the fault, it will be found that its trip point is reduced below that of the breaker nearer the source. This results in tripping the breaker nearest the fault and isolates only that section of the system on which the fault occurs.

As contrasted with slower forms of circuit interrupters, the use of a high-speed circuit breaker results in a material reduction of the peak current of the faulty feeder. A comparison of the interrupting characteristics of common forms of air circuit breakers is given more fully in the comments pertaining to Fig. 5.

The trip-free characteristic of the high-speed breaker permits it to be closed on heavy overloads or faults where the reclosing relays are in the open position. Contrary to the indication of the reclosing devices the breaker in such cases may be closed by means of supervisory or manual control.

DESCRIPTION OF 600-VOLT FEEDER EQUIPMENT

High-speed air circuit breakers were first applied to d-c. reclosing service over five years ago. The construc-

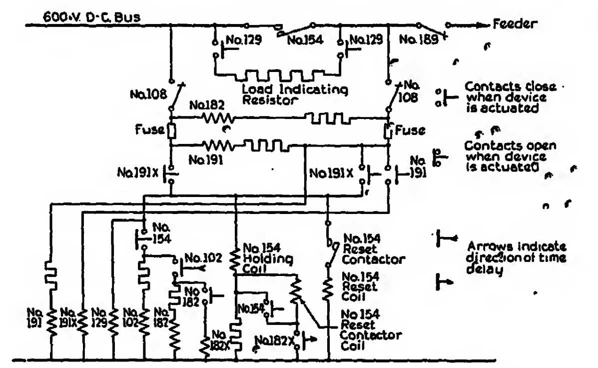

FIG. 3—ELEMENTARY CIRCUIT DIAGRAM OF AUTOMATIC RECLOSING FEEDER

For 600-volt service using a continuous load indicating scheme and suitable for stub-multiple feed in either direction

tion of this type of equipment is illustrated in Fig. 2.

A design of reclosing feeder using a continuous load indicating scheme is indicated in elementary form by Fig. 3. The reclosing relay No. 182 is of the so-called "balanced" type. The restraining (or opening) coil is connected across the load-indicating resistor. The actuating (or closing) coil is connected across the source of voltage. With a short circuit on the feeder, the restraining coil has full operating voltage impressed upon it. This action causes the contacts of No. 182 to open and remain open. Some time later, as determined by the setting of the time delay relay No. 102, the actuating coil is connected across the operating source. Both the actuating and restraining coils now have full operating voltage impressed across their respective

circuits. The relay (No. 182) is so adjusted that under this condition the restraining coil overpowers the actuating coil and the relay contacts remain open. As the load resistance increases, the voltage drop across the load indicating resistor decreases. This decrease also takes place across the restraining coil; consequently, a predetermined load value is reached where the actuating

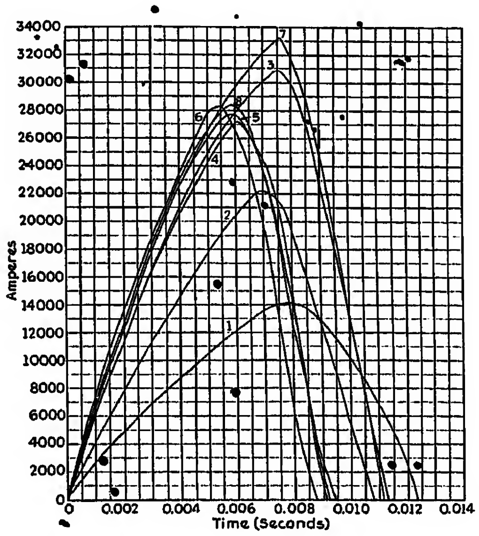

FIG. 4—HIGH-SPEED AIR CIRCUIT BREAKER

Opening a short circuit at 600-volts with different combinations of machines supplying power. Resistance of external circuit 0.002 ohm

Curve No.	Kw. connected to station bus	Maximum rate of rise, amperes per second
1	2,000	3,050,000
2	4,000	4,250,000
3	6,000	6,650,000
4	7,000	6,050,000
5	8,000	7,400,000
6	10,000	7,600,000
7	11,000	7,000,000
8	12,000	7,000,000

coil overpowers the restraining coil and the relay contacts close. The latter operation energizes an auxiliary relay, No. 182-X, which in turn closes the circuit breaker, No. 154. The reclosing relay, No. 182, is so adjusted that it operates at a fixed voltage ratio over a wide range of operating voltage. By this characteristic, the feeder recloses on a fixed value of load resistance, regardless of the value of the source voltage. In case another station is supplying the load (multiple feed), when the same voltage ratio is obtained the feeder recloses.

Control power is obtained from either side by means of the voltage directional relay, No. 191, and its auxiliary, No. 191-X. An isolating contactor No. 129, is used to disconnect the load indicating resistor when the feeder is taken out of service, by opening the control power switch No. 108.

RESULTS OF CURRENT INTERRUPTING TESTS ON 600-VOLT RECLOSING FEEDER

An extensive set of tests was made on a street railway property using the type of feeder as illustrated in Fig. 2. One feeder was installed in a station where the connected synchronous converter capacity (25 cycles) could be varied, in certain steps, from 2000 to 12,000 kw. One set of tests was made in which the short circuit was applied immediately outside the station, giving an external circuit resistance of 0.002 ohm. The results of these tests as given in Fig. 4 show that the peak current increased as the connected machine capacity increased from 2000 to 6000 kw. From 6000 to 12,000 kw. there was no corresponding increase; in fact most of the peak values were slightly under the peak value corresponding to the 6000 kw. condition. This same type of breaker has successfully interrupted currents as high as 61,500 amperes at 600 volts.

The comparative time-current tripping characteristics of the high-speed and other more common forms of circuit breakers may be obtained from Fig. 5. These tests were made at 600 volts, with the same external circuit conditions and with the same amount of con-

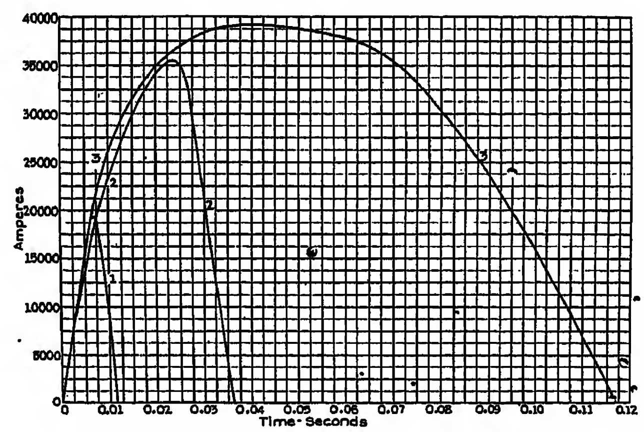

FIG. 5—COMPARATIVE TIME-CURRENT TRIPPING CHARACTERISTICS

Of correspondingly rated magnetically-held high-speed circuit breaker (Curve 1), mechanically latched circuit breaker with fast moving parts and magnetic blowout on arcing contacts (Curve 2), and mechanically-latched circuit breaker with carbon arcing contacts (Curve 3). Tests were made with the same external circuit conditions and with the same amount of connected power

nected conversion apparatus. Curve 1 shows the time-current tripping characteristic of the high-speed circuit breaker as illustrated in Fig. 1. Curve 2 is the corresponding characteristic of a relatively fast panel-mounted mechanically-latched circuit breaker having a magnetic blowout associated with the arcing contacts. Curve 3 illustrates the corresponding characteristic of the usual panel-mounted air circuit breaker (mechanically-latched) having carbon arcing tips.

DESCRIPTION OF 1500-VOLT FEEDER EQUIPMENT

High-speed circuit breakers have been applied to

1500-volt reclosing service. Such an equipment, as illustrated in Fig. 6, makes use of the continuous load indicating scheme as outlined in connection with Fig. 3.

Another application of this type of equipment has been made to cross-tie and sectionalizing points. Fig. 7 illustrates a typical system consisting of three generating stations, designated as Nos. 1, 2, and 3, feeding four track circuits. At convenient points along the system there are installed certain cross-tie and sectionalizing buses. This arrangement results in confining the fault to a particular section without a loss of service on other sections and, in addition, permits the feeder and trolley copper to be used to advantage during normal operating conditions.

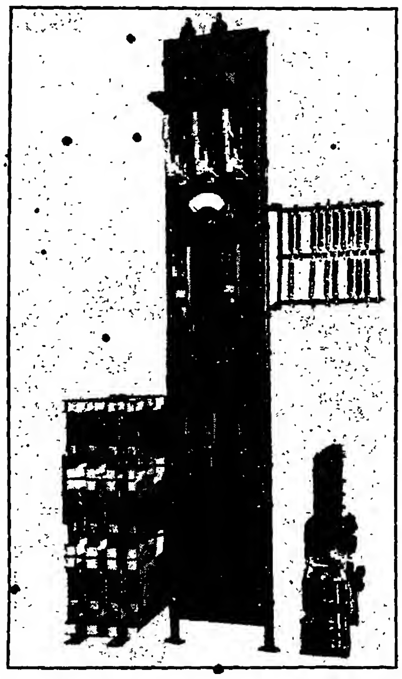

FIG. 6—1500-VOLT, 2000-AMPERE D-C. RECLOSING FEEDER

Using a high-speed circuit breaker and a continuous load-indicating scheme. Circuit breaker and load-indicating resistor shown respectively, to the right and left of the panel

If a short circuit should occur on Track No. 1 in the section fed from station No. 2, not only will the corresponding feeder breaker at station No. 2 be tripped, but also the two breakers which feed each end of the faulty section from the adjacent cross-tie and sectionalizing buses will be tripped. The selective operation of the breakers at these points is obtained by having them trip on outgoing current only, which is readily available due to the polarized tripping characteristics of the type of high-speed breaker covered by this paper. Another characteristic used advantageously in such an installation is the reduced holding coil voltage of the breaker nearest the fault. This characteristic, together with current flowing in the proper direction, gives the desired selectivity.

The breakers usually reclose when voltage has been reestablished for a definite time on the faulty section, either by the station breaker or by the sectionalizing breaker at the other end of the section. By means of supervisory control it is possible also to reclose the sectionalizing breaker from its corresponding bus.

The stub feeders at the end of the system obviously obtain their control from the bus at all times. Those feeding in multiple with other feeders can reclose from the bus (by means of supervisory control) or in response to voltage restoration, on the track circuit. The normal reclosing operation is on voltage restoration.

DESCRIPTION OF 3000-VOLT FEEDER EQUIPMENT

The application of reclosing feeders to 3000-volt d-c. railway circuits includes a number of problems not encountered at the lower voltages. Principal among these is the fact that this voltage has been applied to main line electrification with long trains and also with longer distances between stations. Tests have been made in the field, showing that if, too large a voltage increment is placed on the locomotive, there is danger of suddenly increased tractive effort which will cause the wheels to slip or the draw-bars to snap.

The investigation of this problem has led to the development of a combined load-indicating and load-limiting feeder. The load-indicating resistor determines whether a short circuit exists on the feeder and if load conditions warrant reclosure. If so, the load-indicating resistor is short-circuited, leaving the lower ohmic-value load-limiting resistor in circuit. The purpose of the latter resistor is gradually to raise the feeder voltage by suitable increments.

In this way the load-limiting portion of this type of feeder serves as an accelerating resistor. The most severe condition is one where the locomotive is in full parallel outside the station and is being fed from the remote station. The difference in voltage across the open terminals of the reclosing feeder breaker, is equal to the drop in the positive and return from the remote station. Such differences in voltage may be as high as 1200 volts. Under these conditions, the reclosing feeder has to decrease this difference in voltage, by suitable steps, to zero or, in other words, raise the locomotive voltage from 1800 to 3000 volts.

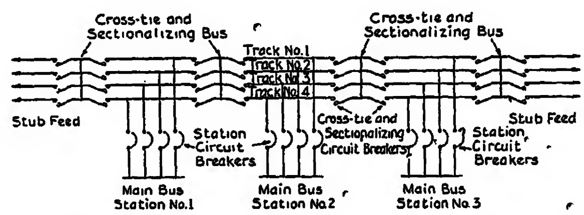

FIG. 7—TYPICAL ONE-LINE DIAGRAM SHOWING APPLICATION OF CROSS-TIE AND SECTIONALIZING CIRCUIT BREAKERS

To a four-track system. Current must flow away from cross-tie and sectionalizing bus in order to trip circuit breaker on faulty section

Automatic Mercury Rectifier Substations in Chicago

BY A. M. GARRETT[1]

Associate, A. I. E. E.

Synopsis.—Two automatic mercury-vapor rectifier substations having 3000-kw. 5000-ampere, 600-volt rectifiers are described in this paper. These rectifiers are the largest installed in this country. The reasons for the selection of this type of converting equipment instead of the rotary converter are enumerated. Information is given on the auxiliary apparatus and the control arrangement.

THE placing in service recently of two mercury-vapor rectifier substations in Chicago, automatic in operation, marks the fourth of a series of rectifier installations in this vicinity. The application of approximately 10 rectifiers to steam road electrification service, as well as city traction supply, has perhaps made the Chicago District the representative locality for this new type of converter.

The decision to make the latest units automatic in operation was based on two fundamental reasons,

FIG. 1—3000-KW. MERCURY ARC RECTIFIER AT MAYPOLE AVENUE SUBSTATION

first, to determine whether the so called adaptability of the rectifier to automatic operation would be borne out by practical experience, and second, to demonstrate comparative performance with the automatic operation of the synchronous or rotating converter. Both types serve the same class of load supplying 600-volt energy to the elevated and surface lines systems of Chicago.

Because of the number of rectifiers of the iron tank type originally installed in Chicago or vicinity, the subsequent wide-spread interest in their performance, and the changes and additions in the latest units, making them more applicable to American practise, a word in explanation of the decision to use this type of unit for railway service is necessary.

Although from an operating point of view this decision is based upon a performance not equal as yet to that of the synchronous converter, improvements recently made in rectifiers, together with removal of handicap due to size, are some of the factors which lead us to believe the difference in reliability has practically disappeared.

The usual advantages generally understood to be characteristic of the rectifier are: a converting device simple in design and construction; practically no moving or wearing parts; low maintenance and inspection costs; absence of renewal expense and higher efficiencies. In addition, the advantages which are outstanding for rectifier installations when located in metropolitan areas are the use of water for cooling purposes instead

FIG. 2—CONTROL AND FEEDER SWITCHBOARD, MAYPOLE AVENUE SUBSTATION

of air, absence of noise and vibration, and the elimination of massive foundations and ventilating duct construction.

The increased number of facilities required with the installation of the modern converter of the rotating type has become a problem and a matter of concern from an operating point of view, as well as that of investment. Whether located in leased space below the street level in a commercial building, or in a substation building of the conventional type generally found in the outlying territory, the present synchronous converter must be provided with enclosures to which are

1. Engineer of Substations, Commonwealth Edison Company, Chicago, Ill.

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connected extensive space consuming air intake and exhaust systems, air cleaning and blower equipment, part of which is fitted in and around massive foundation work. These facilities or a modification of them must be provided for ventilation of the unit or for noise mitigation, or for both. The use of the mercury rectifier appears to be the answer to these problems which cannot be solved satisfactorily when the older type of converter is used.

The two rectifiers which are of the largest ampere size installed to date in this country, were manufactured by the American Brown-Boveri Electric Corporation. This capacity is obtained from a single cylinder arranged with 12 water cooled anodes. The rating of unit is 3000 kw. 5000 amperes, 600 volts, with 50 per cent overload capacity for two hours and 200 per cent load for one minute. Although nominally known as a 600-volt outfit, a no-load tap arrangement permits a range of voltage on the output side of the rectifier of 575 to 650 volts in steps of six full capacity taps. The rectifier which receives its a-c. energy from oil insulated self-cooled transformer is operated from the three-phase 12,000-volt, 60-cycle grounded neutral system of the Commonwealth Edison Company. The rectifier unit together with the 600-volt feeders are fully automatic, the 12,000-volt switching equipment is remote controlled from the nearest attended substation in the territory. The 12,000-volt supply to the rectifier substation is furnished in two lines arranged in a loop formation from the same attended substation.

The pump equipment for exhausting the air and gases from the cylinder is different from previous units in that two sets of pumps are used instead of one, and the mercury vapor pumps are separated from the rotary vacuum pumps, and are mounted upon the rectifier cylinder making a shorter and more effective piping arrangement with the condensing chamber.

Because the mercury rectifier is essentially a static conversion unit, devices necessary to prepare it for automatic operation are relatively few in number.

The starting of the unit is controlled by a time clock which can be set at any predetermined time to place in motion the customary control equipment commencing with the master control relay which functions in sequence to close the a-c. oil breaker, strike the ignition and excitation arcs within the cylinder, start the cooling water, and close the d-c. breaker connecting the unit to the 600-volt bus and the pick-up load that is available. Ordinarily the total time for this operation is less than one minute. To shut down the unit the master relay trips the a-c. oil breaker which through auxiliary contacts cuts off the excitation and trips the d-c. breaker. To the a-c. breaker operation is added the function of reclosing the three trials at reclosing before locking out after the third attempt.

The pumping equipment, which is used to maintain vacuum within the cylinder, operates independent of any of the other automatic functions of the unit and the control for this equipment is in operation at all times whether the rectifier is connected to the system or not, except at such times that the unit may be taken out of service for repairs or other reasons. This control consists essentially of a hot wire gage operating on the Wheatstone Bridge principle; arranged so that two of the arms of the bridge are subject to the gas pressure within the cylinder, while the other two are exposed to the pressure of the atmosphere. The difference in resistance due to difference in pressure causes a current to flow through a vacuum meter which is calibrated to indicate the vacuum directly in millimeters of mercury. This meter also carries contacts which control the action of the mercury and rotary pumps placing in operation the mercury pump only when there is a high vacuum, both mercury and rotary pumps when a medium vacuum exists, and operates the lockout relay taking the rectifier off the system when low vacuum is indicated.

The amount of water supplied to the rectifier is regulated in accordance with the load demands through the registering of the temperature of the discharge water upon a thermostatic device which in turn controls the solenoid operated water valves.

Briefly the entire installation is protected against overloads, short circuits, overheating of the rectifier cylinder, failure of the water supply, failure of the auxiliary power supply, and high-voltage surges as follows:

Overload relays of the induction type located on the high-voltage side of the transformer protect against overload and short circuit conditions. This action is selective with the d-c. breaker.

A series of continuous overloads which may occur below the setting of the overload relays and cause undue heating of the rectifier, if persisted in long enough, is guarded against by means of a thermal relay. The rectifier is further protected against overheating by a temperature relay which gives a visible warning when the temperature of the cylinder reaches 60 deg. cent. and at 65 deg. cent. locks out the substation. Protection is afforded to the equipment in case the cooling water to the vacuum pumps fails, fuses in the supply circuit to the pumps blow, or the service of the supply circuit is interrupted or fails.

Protective resistance and spark-gaps connected to the anode leads mitigate the effect of high-voltage surges.

An 8000-ampere Westinghouse carbon breaker provides the switching device for the output side of the unit, as well as protecting the rectifier against short circuit, overload, and reverse current conditions.

Further protection as to overload and short circuit conditions on the d-c. side of the rectifier including selectivity with the Westinghouse breaker is provided

by the General Electric moderate speed breakers with which each feeder is equipped. The breakers are automatic and reclosing in action.

To reduce the amount of scale forming matter which may deposit in the water passages around the cylinder due to roiled or muddy water, the cooling water is first passed through sand filters. It is expected that the amount of cleaning of the water chamber will be materially reduced.

The interior of the substation building is designed to meet the requirements of this type of conversion unit, its auxiliaries, and switching equipment. Generally the arrangement is similar to that of a rotating unit except for the absence of those features mentioned before. The exterior architecture of the building presents a structure pleasing in outline and creditable in appearance to the neighborhood.

The length of time the two units have been in service is much too short to gain any information as to operating performance. It may be said, however, that the two rectifiers were placed in service just prior to the time the heavy winter load occurs on the traction systems, and although subject to only a short seasoning period, the units have shown good performance up to the first of January, carrying at times integrated loads almost equal to the rated capacity.

Abridgment of

Lightning

Progress in Lightning Research in the Field and in the Laboratory

BY F. W. PEEK, Jr.*

Fellow, A. I. E. E.

I. Introduction

While there is still much to learn, lightning may be said to be now at least on an engineering basis since it is expressed numerically in volts and amperes. It has been removed from the realm of the "medicine man."

The following indicate how rapid the progress has been: The wave shape of lightning has been pictured by the cathode ray oscillograph; the time required for a cloud to discharge has been measured by the cathode ray oscillograph; the attenuation of lightning waves traveling on a transmission line has been determined; natural lightning waves have been reproduced in the laboratory where their effects on transmission lines, insulators, insulation, transformer, and protective apparatus have been studied at will; a lightning generator producing over 3,600,000 volts has been constructed and waves from this generator have been sent over transmission lines to test full size transformers and other apparatus to determine how to make them highly resistant to lightning; scientific work on the time lag of gaps and insulation has been extended, etc.

II. Laboratory Research

The Lightning Generator. Up to the early part of 1927 the laboratory lightning work had progressed so far,[1] that it seemed important to double the 2,000,000 volts available at that time. This high voltage was desirable so that full size apparatus could be tested and results obtained without extrapolation. A 3,600,000-volt generator was built and is in satisfactory operation; and an extension is now available so that a voltage about 5,000,000 is obtainable. (On January 25, 1929, after the original writing of this paper, the voltage of the lightning generator was increased to 5,000,000 volts, and laboratory lightning research started at that potential.)

A radically new method to obtain the very high voltages was devised by the author.[2] The effect is of adding two, three, four, or more of the original generators in series at the proper instant so that all of the respective impulse voltages add together. No rectifiers are used. The a-c. voltage is applied directly to each unit generator.

Wave Shape. In the first studies of transients, wave shapes could not be pictured directly; it was necessary to calculate them. The cathode ray oscillograph[6] now affords a means by which oscillograms can be taken readily. It is interesting that these oscillograms measuring time in microseconds check the early work.[2] Fig. 5 shows a typical oscillogram. This particular wave reaches its crest in a fraction of a microsecond, and then decays to half value in five microseconds.

Sparkover of spheres, points, and insulators

The full line curves in Figs. 8 and 11 give the sparkover voltages for different gaps with the Pittsfield high voltage laboratory "standard wave" and other waves.

The effect of wave shape on the lightning sparkover

With the exception of gaps between electrodes producing a uniform field the lightning or impulse sparkover voltage is always appreciably higher than the 60-cycle sparkover voltage. The steeper the wave or the shorter the duration of the transient, the higher the crest sparkover voltage. The lightning breakdown

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1. See complete paper for bibliography.

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voltage will thus vary because lightning surges vary. The ratio of the lightning to the 60-cycle crest sparkover voltage is always greater than unity. Some years ago, this was termed the impulse ratio.[2] Under the usual severe lightning conditions in practise, insulator sparkover voltages give an impulse ratio of two. This has been well established by comparing the lightning sparkover voltages of insulators as measured in the field by

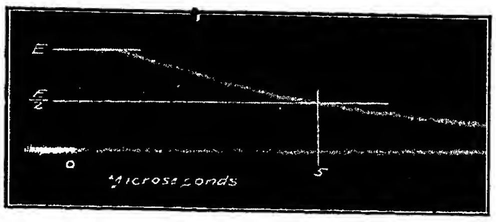


Fig. 5—Typical Five-Microsecond Wave of Lightning Generator

the surge voltage recorder and the klydonograph with the 60-cycle sparkover voltage. The impulse ratio is thus an indication of the effective duration of the wave. The wave in Fig. 7 gives approximately an impulse ratio of two. Points measured on transmission lines are indicated on one curve of Fig. 11.

Whether the front or the tail of the wave is the

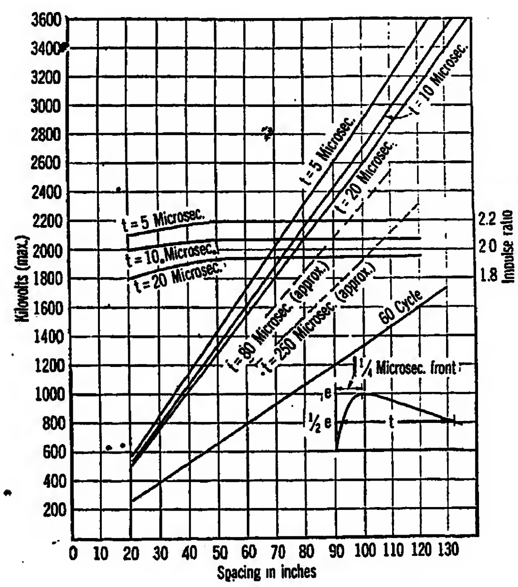


Fig. 8—Point-Gap Sparkover for Different Lightning Waves

See Fig. 5 for oscillogram of five microsecond wave.

controlling factor in determining the lightning sparkover depends upon the voltage applied. This is well illustrated in the oscillograms of Fig. 13 representing actual test records on a 19.9-cm. point-gap. The same wave shape was used throughout these tests.

Tests were also made with waves rising more or less uniformly at various rates and with breakdowns always occurring on the fronts. The results are shown in Fig. 15. For the gap used in Fig. 15, the impulse sparkover voltage approximately equals the 60-cycle sparkover when the time from application of voltage to complete breakdown is approximately 1000 microseconds. This

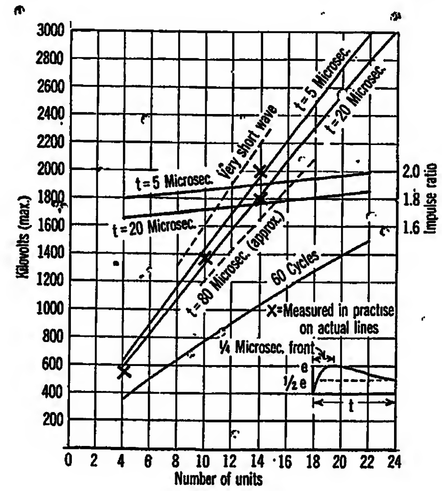


Fig. 11—Lightning and 60-Cycle Sparkover Curves of Suspension Insulators for Different Waves

See Fig. 5 for oscillogram of five-microsecond wave

shows the effect of wave-front steepness increasing the sparkover voltage as previously noted.

Standard tests in the laboratory are made by gradually increasing the impulse voltage until sparkover occurs on 50 per cent of the applications. The instantaneous breakdown voltage when the front is relatively short then depends largely upon the duration of the tail.

If the impulse ratio is the same the results on solid and liquid insulation are approximately the same whether the standard wave, the lightning wave, or a wave with a slowly rising front is used. The three waves are illustrated in Fig. 17.

When the maximum voltage of the lightning impulse

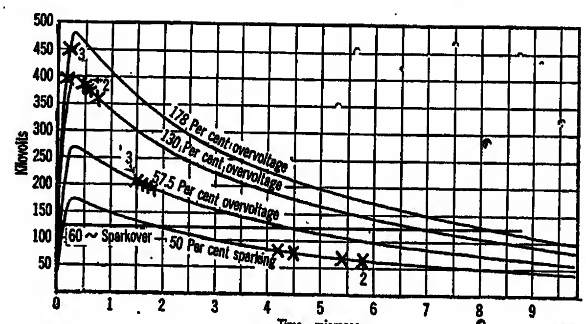


Fig. 13—Sparkover of a Point-Gap with a Constant Wave Shape at Various Applied Voltages

causing an insulator sparkover is measured by a sphere, surge-voltage recorder, or klydonograph, and the 60-cycle crest flashover voltage is known, the effective duration of the wave is also obtained. For example, the lightning sparkover of insulator strings measured in the 220-kv. lines of the Pennsylvania Power & Light Company were found to average about

2000 kv. For these insulators the 60-cycle sparkover was about 1000 kv. This indicates an average impulse ratio of 2.0. The usual impulse ratios of natural lightning varies between 1.8 and 2. The crosses in Fig. 11 for four,- ten- and fourteen-unit insulator strings are flashover voltages due to natural lightning as measured by surge voltage recorders. In a few cases, impulse ratios as high as 2.7 were obtained. These impulse ratios show that the effective duration varied from 1 to 20 microseconds, where the effective duration is the time that the voltage is above half voltage, or approximately the time above the 60-cycle sparkover. Such waves are illustrated in Figs. 5 and 7 and were actually measured by the cathode ray oscillograph. Thus, a wave giving an impulse ratio between 1.8 and 2 on line insulation represents the average severe field conditions, and the standard laboratory wave, established long before measurements were available, is confirmed as simulating practical conditions.

The above does not mean that actual lightning sparkovers are always caused by waves with fronts as

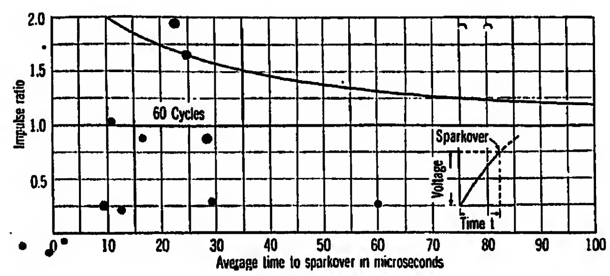


FIG. 15—SPARKOVER VOLTAGE FOR WAVES RISING UNIFORMLY AT VARIOUS RATES

steep as those in Figs. 5 and 7. In the usual laboratory tests the whole wave is used and the front has very little influence. In practise, lightning sparkovers may occur in this way or on the rising front of a moderately steep wave as illustrated in Fig. 17. If the impulse ratio is the same the results are the same. Laboratory tests are also made on the wave front.

The lightning wave secured on the Pennsylvania Power & Light Company line this last summer had a duration above half voltage of about 20 microseconds.

The grading shield. An important function of the grading shield is to cause even distribution along the string. This strengthens considerably the path along the insulator surfaces to lightning and forces the arc to take place between the rings which may be set for a lightning sparkover voltage higher than that of the non-shielded string. Destructive cascading is thus prevented. In this way the gain in voltage may be as much as 10 per cent to 12 per cent, and can be checked by comparing the lightning sparkover of the non-shielded string with the needle-gap lightning sparkover of the distance between rings. For instance the sparkover voltage of a 16-unit non-shielded string from Fig. 11 is 2050 kv. at 20 microseconds. For 85 inches (from Fig. 8) between rings, when the sparkover occurs on a shielded string, it is 2200 kv. For the 20-microsecond wave this is usually over 10 per cent for long strings. For very steep waves it may be more. The difference in sparkover voltage is not appreciable with longer waves.

While the sparkover voltage to lightning waves may be increased by the shield, the 60-cycle sparkover voltage may be lowered. This is not a handicap because lightning surges having an impulse ratio of unity and thus corresponding to 60-cycle waves have never been observed in practise. The dry 60-cycle shielded sparkover voltage might be somewhat increased by using *very* large shield surfaces free from sharp ends or points. However, there can be no gain in practise in this way because the large surfaces would be reduced to equivalent "points" in 60-cycle voltages when wet by the first raindrop. Lightning sparkover voltage is not affected by rain.

That shields prevent deterioration of the units in a string through improved distribution of voltage stresses is forcibly illustrated in tests. After a few lightning sparkovers, insulator units fail in the non-shielded strings while there are no failures in the shielded strings.

In addition to the actual increase in lightning sparkover voltage discussed above, there is also an apparent increase which is probably of more importance. When the energy of the lightning generator is limited, it is necessary to supply a higher voltage to a shielded string to cause sparkover. This apparent increase in sparkover voltage may be of a higher order than the actual increase. The extra voltage must be generated because of the energy dissipated by the "barrel" of corona arcs between the edges of the rings. The gain has been observed when the energy available approximated that in an average span and should be an approximate measure of the effect in practise since there is one shield for each line per span. This energy dissipating effect by corona has been made use of by purposely designing grading rings of flat strap material in place of smooth surfaced pipes.

Wood poles The insulating value of a wood pole to lightning voltages has been measured up to 3,600,000 volts. The measurements show that the strength of wood poles of such varying degrees of wetness and dryness as might occur in practise, range from 100 to 300 kv./ft. A good average value is 180 kv./ft. With a lightning rod a part of the insulation of the pole could be utilized and protection from splitting afforded at the same time by placing a gap in series with the lightning rod. (See complete paper for gap dimensions).

Transformers. The new lightning generator has made possible invaluable studies on full size transformers and insulation arrangements.

Cathode ray oscillograph records of surges on trans-

formers are taken and the voltage distribution is measured throughout the winding. This last measurement is of extreme importance since it shows that in the usual transformer the voltage distribution is not constant but varies with steepness and duration of the impulse or the frequency of the transient. High frequencies and steep impulses may cause excessive voltages at any part of the winding. The ideal transformer would be one in which the voltage distribution was the same for all frequencies and wave shapes. Fortunately it has been possible to accomplish these results by the shielded design, which is an entirely new type. It will not be necessary to go into details here as this transformer is described elsewhere.[8] Fig. 24 shows the results of tests on an actual transformer. In the shielded transformer the impulse and high frequency distribution is shown to be practically the same as the 60-cycle distribution.

Briefly, the reason for the varying distribution of voltage in a non-shielded transformer is as follows: The initial lightning distribution is determined by the distribution of the capacity in the windings and the 60-cycle or long duration voltage distribution by inductance. If the voltage distribution as determined by these factors is not the same an oscillation results until the distribution corresponds to that of the inductance. The shields make the capacity and inductance distribution correspond. The action of the capacity is instantaneous and there is no oscillation.

III. Field Research

Research on Transmission Lines

During the past few years a number of the operating companies in collaboration with the manufacturing companies have obtained some very important measurements, particularly of lightning voltages on transmission lines.[9,10] These measurements were obtained with the klydonograph or surge voltage recorder connected at various points along the transmission lines.

Very valuable data was accummulated which gave further information as to the voltage, polarity, wave shape, and attenuation of lightning waves on lines. The general nature of the waves was briefly as follows: The maximum voltage found was about 2800 kv.; in general, most high-voltage surges indicated negative cloud discharges, although a few obtained indicated positive strokes; the impulse ratios of the waves were around 2.0, and the effective durations—that is; the time the waves were above half voltage—were from one to twenty microseconds; the attenuation was very rapid, particularly for the very high crest voltages where excessive corona would exist—for example, it was found that a 3000 kv. wave would be reduced to half value in traveling about two miles.

Measurement of Lightning Waves and Time Required for a Cloud to Discharge with the Cathode Ray Oscillograph

In order to make proper use of the oscillograph, it was necessary to devise a means of establishing the cathode beam and the sweeping circuit and to have the complete set-up connected to the line as the lightning wave reached it. With the equivalent "switching circuit" developed for this, the complete operation was accomplished in about one microsecond—that is, one-millionth of a second.

(*a*) *Pittsfield measurements.* In the Pittsfield measurements the antennas consisted of three parallel wires 120 ft. long and 40 ft. above ground. The wires were grounded through a 2,000,000-ohm resistance, and connection to the oscillograph was made. With this arrangement the lines assume a potential opposite to that of the cloud when the lightning discharge takes place. Since the charge cannot move along this short line, but must be dissipated by leakage, the potential of the conductors rises at a rate and to a magnitude dependent upon the collapse of the cloud field. The time for this conductor voltage wave to reach maximum is thus a measure of the time required for the cloud to discharge. Fig. 27 shows two of the four antennas waves obtained. The wave fronts are

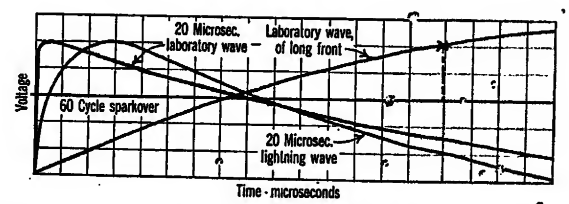


Fig. 17—Sparkover Voltage for Various Waves

of the order of one to two microseconds. The induced voltage crests on the antennas were from 50 to 75 kv.

(*b*) *Pennsylvania measurements.* A very good natural lightning wave obtained on the 220-kv. line is shown in Fig. 28. The front of this wave practically reaches its maximum in 5 microseconds, decreases to half value in 20 microseconds, and reaches zero in 40 microseconds. The oscillating ripple is apparently due to a local flashover[12] and is not really part of the original wave. A reproduction of this wave by the laboratory lightning generator is also shown in Fig. 28. The effects of the wave are very similar to the standard wave of Fig. 7 and the impulse ratio for insulator sparkover corresponds to those determined by the surge recorder or klydonograph readings.

IV. Lightning on Transmission Lines and Apparatus

Voltage

The available data still confirm the rule that the maximum induced voltage on a transmission line depends upon the height of the conductors above ground or.

$$V = h\, g\, \alpha$$

Where V = volts, h = average height of conductor in feet, and α depends upon rate of cloud discharge and the initial distribution of bound charge on the line.

Calculations indicate that under the usual assumed bound charge conditions, an induced voltage wave high enough to cause insulator flashover can result only from a rapid collapse of the electrostatic field of the cloud. Accordingly, this must involve a traveling wave

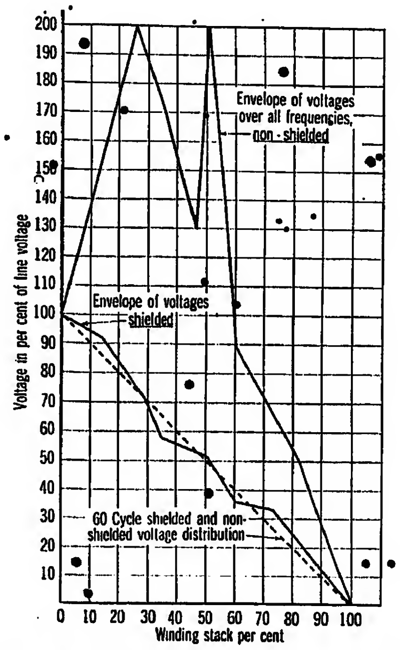


FIG. 24—VOLTAGE DISTRIBUTION AT ALL FREQUENCIES OF SHIELDED AND NON-SHIELDED TRANSFORMERS

of steep front or of short effective duration. A steep wave front would also occur with a surge imposed on a conductor by a direct stroke to it. The maximum voltage wave that can travel on the line and reach the apparatus is determined by the line insulation. The waves in practise are generally non-oscillatory and have a wide variety of shapes. However, the waves usually causing insulator sparkover give an impulse ratio of the order of two (2.0), and indicate an effective

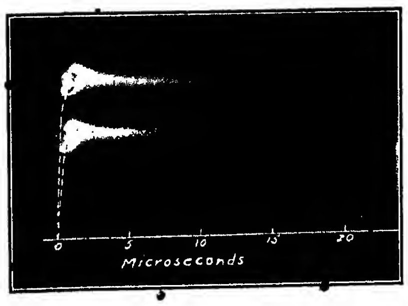


FIG. 27—OSCILLOGRAM OF NATURAL LIGHTNING MADE ON SHORT LINES—PITTSFIELD 1928. DRAWN DOTTED LINES INDICATE APPROXIMATE FRONTS

duration of 1 to 20 microseconds above the 60-cycle flashover value.

The Ground Wire. Statistical data still confirm the value of the ground wire. These data indicate that outages due to insulator arc-overs are reduced from one-half to one-tenth or more after the installation of the ground wire.

Lightning Proof Transmission Lines and Coordination of Transformer Insulation and Line Insulation

The ideal line would be as low in height as practicable, be protected by one or more ground wires, and be well insulated with insulators protected by grading shields. The transformer insulation should be somewhat stronger than the bushing flashover voltage, which in turn should be higher than the flashover voltage of the insulators in the immediate vicinity of the line. By immediate vicinity is meant that the coordinated insulation should start within 75 ft.

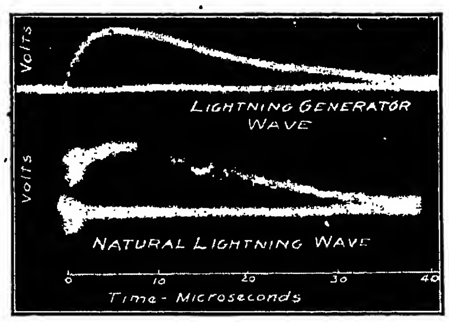


FIG. 28—COMPARISON OF NATURAL LIGHTNING WAVE MEASURED ON TRANSMISSION LINES WITH CATHODE RAY OSCILLOGRAPH WITH AN ARTIFICIAL LIGHTNING WAVE MEASURED IN THE SAME WAY

of the apparatus and preferably extend out at least one-half mile. Such arrangement of the insulation should not increase outages. As a precaution, extra ground wires may be added on the coordinated section to provide against local disturbances. However, where the line is badly exposed to direct strokes special precaution should be taken in the design of the tower, so that side flashes are not likely to take place from ground wire to conductor. Rods might be used and special precautions taken as to length of span, ground resistance, distance from conductor to ground wire, etc. Extra ground wires in sections may be necessary to assure immunity against direct strokes.

FARADAY CENTENARY IN 1931

Preliminary plans for the celebration of the centenary in 1931 of Faraday's epoch-making discoveries are reported by the *Electrical World* to have been made in London at a meeting of representatives of scientific, electrical and other societies held at the Royal Institution under the presidency of Sir Arthur Keith. The time chosen provisionally for the celebrations was the third week in September, 1931, and it was decided to set up two small committees, representing the scientific and industrial interests, to make the necessary plans and to insure that the celebrations shall be attended by interested persons from all parts of the world.

Bushing-Type Current Transformers for Metering

BY A. BOYAJIAN[1] and W. F. SKEATS[2]

Fellow, A. I. E. E. Associate, A. I. E. E.

Synopsis.—This paper describes a new development in connection with bushing type current-transformer metering circuits. While this development utilizes the two-stage principle and has the same order of accuracy as that of two-stage current transformers, it is different from the conventional two-stage current transformers in that it does not require two-stage wattmeters and watthour meters, but may be used with any wattmeter or watthour meter. The principle and connections of the transformer are explained, and performance curves of a typical unit are given.

* * * * *

INTRODUCTION

THE great simplicity, reliability, and low cost of the bushing-type current transformer have led engineers to an effort to improve its accuracy to such a point as will be satisfactory for metering purposes. The introduction of the two-stage principle[3] by Brooks and Holtz, six years ago, marked a satisfactory improvement in accuracy, but the two-stage principle as applied so far has required special two-stage wattmeters and two-stage watthour meters. There has still remained, therefore, the need for a bushing-type current transformer that would have metering accuracy and could be used with any wattmeter or watthour meter. In the development of the arrangement described below, which satisfies this requirement, the two-stage principle has been retained and such additional features have been incorporated as would make it adaptable to single-stage wattmeters and watthour meters.

CIRCUIT OF THE NEW CURRENT TRANSFORMER AND THEORY OF ITS OPERATION

Fig. 1 illustrates diagrammatically the conventional two-stage current transformer and a two-stage wattmeter or watthour meter. $P_1 S_1$ is the first stage of the current transformer feeding the first-stage current-coil C_1 of the meter W. The current in C_1 differs (vectorially) from the correct secondary current by the exciting current in P_1 divided by the turn ratio of the transformer. The second-stage transformation aims to put into C_2 a current equal to this difference. In the second stage of this current-transformer, P_2' and P_2'' act jointly as the primary; that is, the net ampere turns of P_2' and P_2'' act as the primary ampere turns, inducing a corresponding secondary current in S_2, which flows into the second-stage current-coil C_2 of the meter. The net ampere turns of P_2' and P_2'' are the exciting ampere turns of the first stage and thus the current delivered to S_2 and C_2 represents and makes up for the exciting current error of the first stage. In transforming the exciting current of the first stage, the second-stage current transformer requires an exciting current, so that the exciting current correction by the second stage is not 100 per cent exact. However, since the residual error is the exciting current of the exciting current, it is of second order of magnitude as compared with the error of the first stage or as compared with the error of an ordinary current transformer of the same proportions.

In order that the two stages may perform without interference from each other, it is necessary that the two circuits have no appreciable mutual impedance.[4] One obvious method of accomplishing this is to separate the current coils C_1 and C_2 from each other and provide a separate potential coil for each one to react with.

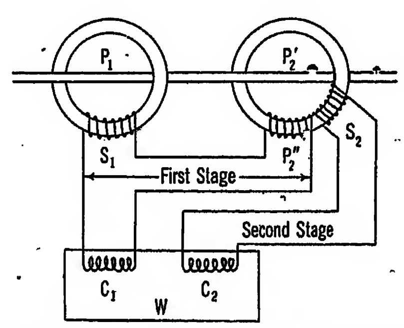


FIG. 1—TWO STAGE CURRENT TRANSFORMER WITH SPECIAL WATTMETER HAVING TWO CURRENT COILS

This is the practise followed in most of the two-stage current transformer applications, requiring special wattmeters and watthour meters. This disadvantage has been obviated in the present arrangement as follows:

For the proper performance of the two stages, it is not necessary that there should be no mutual impedance between the two circuits at any point, but that there should be no *net* mutual impedance. Accordingly, C_1 and C_2 may have any mutual impedance at any point provided that it is neutralized by an equal and opposite mutual impedance at another point. If C_1 and C_2

1. General Electric Company, Pittsfield, Mass.

2. General Electric Company, Schenectady, N. Y.

3. See *The Two-Stage Current Transformer*, by H. B. Brooks and F. C. Holtz, A. I. E. E. TRANS., 1922, p. 382.

Presented at the Regional Meeting of the Middle Eastern District of the A. I. E. E., Cincinnati, Ohio, March 20-22, 1929.

4. By the mutual impedance between two circuits is understood the ratio (vectorial) of the voltage in one circuit produced by current in the other to the current flowing in the other circuit. As far as the authors know, this conception has to date been limited to mutual inductance or mutual reactance, but if the two circuits have a part in common it is obvious that current flowing in the one will give rise to an in-phase voltage in the other due to the resistance of the common part.

are combined into a single current coil C (Fig. 2) as in any conventional wattmeter or watthour meter, the mutual impedance between the first and second stage circuits is the impedance of the coil C, and therefore it is necessary and sufficient to provide another impedance common to the two circuits and equal and opposite to C. This is accomplished by the auxiliary impedance Z and the transformer T. The impedance Z is substantially equal to the impedance C times the ratio of transformer T, and the transformer T accomplishes the desired reversal of sign so that one can neutralize the other. To make this clearer, assume that the switch A in the second stage is opened. The first stage current flowing through C and the primary T, will naturally circulate a corresponding current in the secondary of T through the impedance Z. If now we trace the second-stage circuit beginning at a and ending at b, through Z and C, we find that there are two

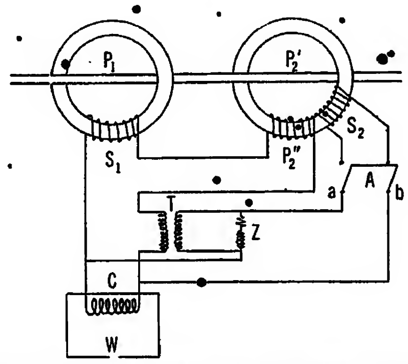


Fig. 2—Two Stage Current Transformer with Standard Wattmeter

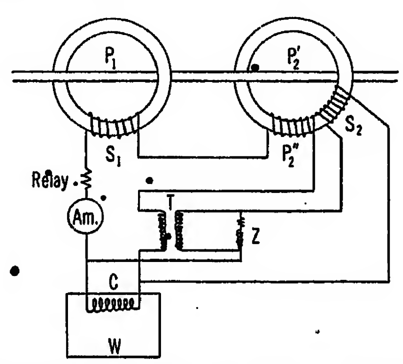


Fig. 3—Two Stage Current Transformer with Standard Wattmeter, Ammeter, and Relay

impedance drops in it, one at Z, the other at C, and that these two are opposite to each other so that no net voltage appears from a to b induced from the first stage current. The equality of the two drops is accomplished by the equality of the two impedances, while the opposition of the drops is accomplished by the fact that the secondary induced current of T must be opposite to its primary current. Thus, the net mutual impedance between the first-stage and second-stage circuits is rendered zero; and, therefore, if the switch A is closed, the second-stage current transformer delivers its current into the current coil C of the meter unaffected by the first-stage current C. Thus, both the first and the second stage currents flow simultaneously in one and the same coil C without any interference.

If Z is vectorially identical with the impedance of C, obviously the exciting current of T will cause the drop across Z to be slightly (vectorially) different from that across C. This error may, if desired, be compensated by making Z proportionately (vectorially) different from C. The magnitude of this error, however, is very small compared with the general improvement accomplished, especially in the bushing-type current transformers; because, first, the auxiliary transformer T is a very low-voltage transformer and can therefore be made far more accurate than the high voltage units

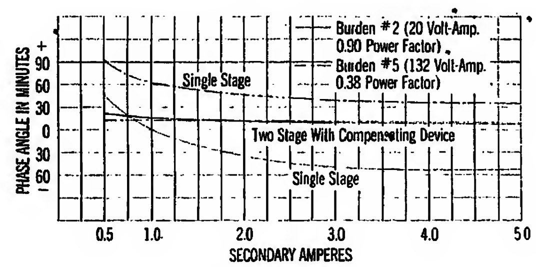


Fig. 4a—Performance Curve

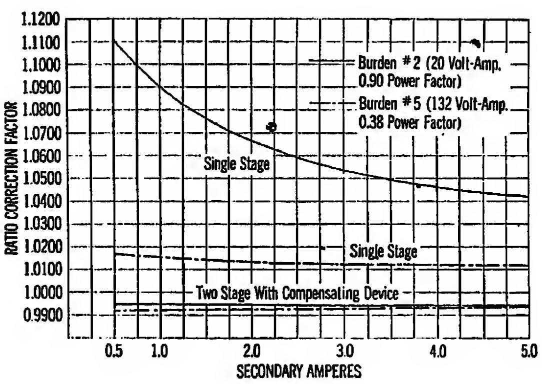


Fig. 4b—Performance Curve

P_1, P_2; and second, the auxiliary transformer T need not be bushing type, but of any high accuracy type, and thus again its error will be almost negligible for the circuit conditions. T is not to be mounted on the bushing but at any convenient point on the switchboard near the meters.

Fig. 3 illustrates the connections of such a current transformer arrangement with a number of instruments. Since great precision is necessary only in the meters and not in the indicating instruments or relay coils, only the watthour meter is shown included in the second stage. This leads to greater accuracy by reducing the burden and exciting-current of the second stage. In such applications, the auxiliary impedance Z must obviously represent the impedance of only that part of the burden which is to be "two-staged." The

auxiliary impedance naturally adds to the burden of both stages, but since it duplicates only that part of the burden which is to be "two-staged," it adds only a small amount to the total.

PERFORMANCE CURVES

Figs. 4A and 4B show performance curves of a 300-ampere turn, 60-cycle unit designed for a 132-kv. bushing. Single stage curves taken on the same unit, and using both first stage and second stage iron are also shown for comparison. The curves were taken for standard burdens No. 2 (20 volt-amperes, at 0.90 power factor) and No. 5 (132 volt-amperes, at 0.38 power factor). It will be noted that errors in phase angle of + 36 min. and − 52 min. at full load have been reduced to + 10 min. and + 8 min. respectively, whereas errors in ratio of 4.2 per cent and 1.2 per cent have been reduced to 0.6 per cent in each case. Moreover, whereas the uncompensated transformer showed much larger errors at low values of current than at high values, the two stage transformer with the compensating device is very nearly as accurate with 0.5 secondary amperes as with 5 secondary amperes.

Table I shows the final correction factor for each burden at 0.5 secondary amperes and at 5.0 secondary amperes and at various power factors.

The table shows that the combined ratio and phase angle error changes from 1.1 per cent at 10 per cent of rated secondary amperes to 0.8 per cent at full rated secondary amperes at 80 per cent line power factor, with additional improvement as the power factor is increased.

TABLE I
FINAL CORRECTION FACTOR

Line power factor	0.5 secondary amperes		5.0 secondary amperes	
	Burden No. 2	Burden No. 5	Burden No. 2	Burden No. 5
0.90 lead	0.994	0.997	0.995	0.995
0.95 lead	0.993	0.996	0.995	0.995
1.00	0.992	0.994	0.994	0.994
0.95 lag	0.991	0.992	0.993	0.993
0.90 lag	0.990	0.991	0.993	0.993
0.80 lag	0.989	0.989	0.992	0.992
0.70 lag	0.988	0.987	0.991	0.992
0.60 lag	0.987	0.985	0.990	0.991
0.50 lag	0.985	0.983	0.989	0.990

The Post College Education of Engineers

BY EDWARD BENNETT[1]

IN the fact-finding stage of the studied movement to "develop, broaden, and enrich engineering education" which has been sponsored by the Society for the Promotion of Engineering Education, the experiences and opinions of practising engineers have been an essential and an important contribution to the study. The study has resulted in a wealth of carefully analyzed information pertaining to the objectives of engineering education, to educational practises and results, and to the possible methods of broadening and enriching educational procedures.

The complete working out and the full realization of some of these possibilities will require the cooperation of the three groups represented on the Institute's Committee on Education, namely: the engineering practitioners, the engineering teachers, and the engineering industries. Under these conditions, it has seemed to the Committee that it is confronted with the opportunity to advance those educational movements requiring the cooperation of these three groups. The Committee has deemed it wise to concentrate its efforts upon a single movement rather than to spread them over several.

Of all the undeveloped educational movements requiring the cooperation of the practitioners, the teachers, and the industries, none seem to the Committee to have greater possibilities of advancing the standards of professional achievement than does the movement to stimulate the continuation of education after college, and to make provision for this post college education.

The continued rapid increase in scientific knowledge and the rapid increase in the diversity and complexity of the engineering applications and the engineering responsibilities combine to make the four year engineering program a less and less adequate preparation for effective engineering work. The S. P. E. E. study has disclosed that very few engineers or teachers propose to meet this situation by requiring all college students to remain upon the college campus for a fifth or sixth year. The solution seems to be rather, to encourage that limited number of graduates which is possessed of the requisite interest and means to enroll in resident graduate courses, as well as the greater number who enter at once upon their engineering apprenticeships, to continue their educational efforts to a greater extent and to a more definite end than at present.

"Is not this field of post college education one of primary responsibility of the professional body? The tradition of the profession has always been that college training is only a part of an engineer's preparation, and that experience in subordinate capacities, under the direction and criticism of qualified practitioners, is an indispensable part of his training," and yet the engineering profession has assumed no responsibilities with reference to this post college training.

1. Chairman, Committee on Education.

The teaching profession assumes the responsibility for only the first part of the engineer's training; the larger industrial organizations have assumed and are assuming greater responsibilities during the period of their apprenticeship courses. Should the engineering profession leave the post-college training entirely to chance, circumstance, and the industries? "Could the profession define in terms that are flexible enough to avoid making a straight jacket and yet explicit enough to be of value, what it expects of the young electrical engineer in addition to his scholastic training in school and college? Could this further training be backed up by some incentive and be given some distinctive recognition? Could the way be prepared for some review of the entire early education and experience of the young engineer—say five years after he is graduated—as a basis of professional certification? Could this plan of certification be tied in as a form of joint sanction with the award of the professional degree by the colleges?"

Considerations and questions such as those recited above lead the Committee to feel that it can render the most effective service,

(a) by seeking to bring the thought of the Institute membership to bear upon the possibilities and the problems of post-college education and upon the responsibilities of the profession relative to this period of training;

(b) by seeking to stimulate the local sections to promote this movement by setting to work to canvass or inventory the post-college needs and the educational facilities of their districts, bringing the two together;

(c) by seeking to act as a center through which a knowledge of distinctive and effective developments in the field of post college education may be made generally known.

The section of the Investigation of Engineering Educations of Bulletin 3 entitled the Continuation of Education After Leaving College contains the following suggestions as to the services and types of courses which the colleges may make available for the purpose of post college education.

1. The colleges may make well outlined reading courses available to such graduates as apply for them.

2. Certain institutions, if properly manned and organized, may offer correspondence courses. Subjects such as contracts and specifications; industrial organization and planning; commercial methods, organizations and law; cost accounting; and financial methods lend themselves to instruction by this means.

3. In certain cases, extension courses for graduate students may be set up in industrial centers in which graduates in particular fields can confer with representatives of the institutions at regular intervals. Post-scholastic courses of the following types may be offered:

(a) Advanced work of the kind given in post graduate residence courses in mathematics, physics, and engineering subjects.

(b) Courses dealing with recent developments, designed to enable graduates to keep abreast of scientific progress.

(c) Seminars for the discussion in the light of fundamental theory of

(A) Allied research problems,

(B) Allied or common design problems,

(C) Allied or common operating or manufacturing problems.

4. The engineering colleges may undertake individually to furnish advisory services to alumni and other engineers in the vicinity of the colleges to assist in such matters as:

(a) Recommended reading courses.

(b) Supplying information as to educational facilities available in the community in which the graduate is located.

(c) Advice and suggestions relative to engineering problems of the kind rendered to students in residence who are engaged in thesis projects.

In addition to the possible post college services rendered by the colleges alone, which are listed above, the following types of courses should be listed.

1. Advanced studies under the joint auspices of the colleges and the industrial organizations; as, for example, the arrangements between the University of Pittsburgh and the Westinghouse Electric and Manufacturing Company, or between the Massachusetts Institute of Technology and the General Electric Company, or between the Bell Laboratories and Columbia University.

2. Advanced and special technical training of an organized character given under the auspices of the employing organization; such as the out-of-hours courses of the Bell Telephone Laboratories, or the design courses of the Westinghouse and General Electric companies.

3. Training courses designed to give familiarity with the organization and practise of a particular company or industry given under the auspices of the employing organization.

For further information relative to the experience which has been had in the field of post college education, any one interested may consult Bulletin 3, (referred to above) or a paper entitled *Seminars for Practising Engineers*, by Edward Bennett, of the TRANSACTIONS of the A. I. E. E. for 1926, Vol. 45, p. 602 or an address entitled The Urban University and Engineering Education* delivered by H. P. Hammond before the Association of Urban Universities November 16, 1928 and reciting the striking results of the recent venture of the Brooklyn Polytechnic Institute into the field of post-college education.

In view of the ends which the Committee is seeking to attain, the chairman has one recommendation which he wishes to make and to urge upon the attention of the Sections at this time. It is that the Sections, particularly in the industrial centers in which Colleges of Engineering are located, each appoint a Committee on Education. It is suggested that the function of the Section committee on education be to canvass the needs and the wishes of the engineers of the district, particularly the younger engineers, and to make these needs and wishes articulate by bringing them to the attention of the college administrations, or the industrial manage-

*Printed in *Milwaukee Engineering*, Vol. IX, Nos. 4 and 5, Jan. and Feb. 1929.

ments, or the engineering authorities in the district, in the form of explicit statements such as the following: Consider a group of 20 men who will enroll in a course in differential equations, to meet one evening a week for a year; or 15 men who will enroll in a course in Advanced Circuit Theory; or 30 men who will enroll in a course in Engineering Economics. What provision can be made to meet the needs of these men?

It is suggested that the local Committee on Education, making its announcements through the Section, the affiliated societies of the district, and through the local press, hold a special meeting or meetings to bring to the attention of those interested the post-college educational opportunities of the district, and to canvass the desires and the purpose of those attending the meeting to embark upon specific lines of work.

In preparing this message for the Committee, the chairman has quoted freely from the letters of other members and from the Bulletins of the Investigation of Engineering Education. The Committee solicits the opinions and the experience of the profession relative to the post-college training period.

Abridgment of

132-Kv. Shielded Potentiometer

For Determining the Accuracy of Potential Transformers

BY C. T. WELLER[1]

Member, A. I. E. E.

Synopsis.—The potentiometer principle is well understood. Its application to the determination of the ratio and phase-angle accuracy of potential transformers is not new, but in unshielded form has been limited to about 66 kv. and in shielded form to about 33 kv. The paper describes a shielded potentiometer for 132 kv., which is designed for ultimate extension to 220 kv.

Introduction

The first potentiometer used in the General Electric Laboratory for determining the ratio and phase-angle accuracy of potential transformers was described in 1909. This "deflection" potentiometer was rated at 33 kv. and remained in service until 1920. By that time many 66-kv. potential transformers had been built so that it became necessary either to extend the voltage range of the potentiometer or to abandon the early policy of having equipment available for testing at full rated voltage. A second potentiometer rated at 66 kv., and differing from the first principally in the type of resistors used, was built and put into operation; but even this greater range soon became inadequate. The accumulated experience showed that the general scheme employed was entirely satisfactory but that a further extension of the voltage range would necessitate radical changes in the construction and arrangement of the resistors, principally to secure better dissipation of heat and to permit shielding against capacitance to ground.

In order to make further extension possible in 1924, the author proposed to construct 100,000-ohm resistor units of fairly large dimensions, rated at 11 kv. each, and to maintain the respective unit shields at the proper potentials by means of a special auto-transformer (in separate sections) of ample rating with suitable taps. Four of the units and one auto-transformer section constitute a complete 44-kv. group; the number of series groups necessary is determined by the voltage range desired. To the best of his knowledge, the proposed arrangement and method of shielding had not been utilized before. The 132-kv. potentiometer herein described incorporates the proposed features.

Objective

The potentiometer desired was one which would (1) cover the range from 6.6 to 132 kv. at first and to 220 kv. by future extention, and (2) conform as closely as practicable to an ideal potentiometer over the entire range.

An ideal potentiometer should incorporate the following features:

a. The d-c. resistance of the unit(s) obtained by means of a low-voltage bridge should remain constant and should equal the a-c. effective resistance at operating voltage.

b. The current in all parts of the resistor(s) should be exactly proportional to, and in phase with, the line voltage.

c. The flexibility required should be obtainable without excessive complications and without sacrificing convenience of operation.

Summary

The installation of three 44-kv. series groups and accessories at Pittsfield was completed in 1928. The

1. General Engineering Laboratory, General Electric Company, Schenectady, N. Y.

2. *Electrical Measurements on Circuits Requiring Current and Potential Transformers*, by L. T. Robinson, A. I. E. E. TRANS., Vol. 28, 1909, p. 1005.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Jan. 28-Feb. 1, 1929. Complete copies upon request.

groups alone occupy about 380 sq. ft. (42 ft. by 9 ft.) of floor space, have a height of approximately 12 ft. and weigh about 65 tons (the first potentiometer complete weighed less than one ton). A "General Description" of the potentiometer is given under that title.

Potential transformers have been tested for accuracy over the range from 6.6 to 132 kv. at 25 and 60 cycles (see comments under "Test Results").

Compared with the ideal outlined:

a. The d-c. resistance of the units is practically constant and agrees with the a-c. resistance within 0.01 per cent.

b. The current in the units is directly proportional to the line voltage at all points but small phase displacements exist. The "net" phase angle of the current at 60 cycles ranges from approximately − 1′ (leading) at 6.6 kv. to − 7′ at 44 kv. in the first group, to − 6′ at 88 kv. with two groups, and to − 4′ at 132 kv. with three groups; the corresponding corrections have the same signs.

c. Transformers rated between 6.6 and 44 kv. in 1.1-kv. steps (with a corresponding increase in ratio) and between 44 and 132 kv. in 5.5-kv. steps can be tested; this includes practically all standard ratings. Odd ratings differing less than 4 per cent from those indicated can be tested without special adjustments, but other odd ratings require an adjustment of the resistance. The ratio (correction factor) is read directly (or by interpolation) for standard ratings but must be calculated for odd ratings; the phase angle is calculated from instrument deflections in all cases.

The complications are not excessive, and the operation is reasonably convenient; provision is made also for operating with the mid-point instead of with the lower end of the potentiometer grounded.

The twelve resistor units and the three auto-transformer sections or shielding transformers are interchangeable respectively.

Conclusions

The accuracy obtainable is sufficient to permit certifying results to within 0.1 per cent in ratio and to within five minutes in phase angle over the entire range; these limits are in accord with our best previous practise.

The potentiometer can be extended to 220 kv. without making radical changes in any of the groups whenever the demand justifies it.

Principles of Operation

The principles of operation of our "deflection" potentiometers, which in comparing voltages utilize deflections as well as null or zero instrument readings, have been described[3] but are again outlined in the complete paper.

Effects of Capacitance

All potentiometer resistance used has been of manganin wire non-inductively wound and immersed in oil. Troublesome resistance changes and appreciable inductance were eliminated. The effects of capacitance are indicated in Fig. 2, and are outlined in the complete paper.

General Description

The 132-kv. shielded potentiometer combines potentiometer resistance suitable for alternating current with shielding transformers and other special auxiliary equipment. In connection with standard power-supply equipment, it is arranged for use in determining the ratio and phase-angle accuracy of potential transformers rated from 6.6 to 132 kv., 25 to 60 cycles and 25 to 1000 volt-amperes, respectively.

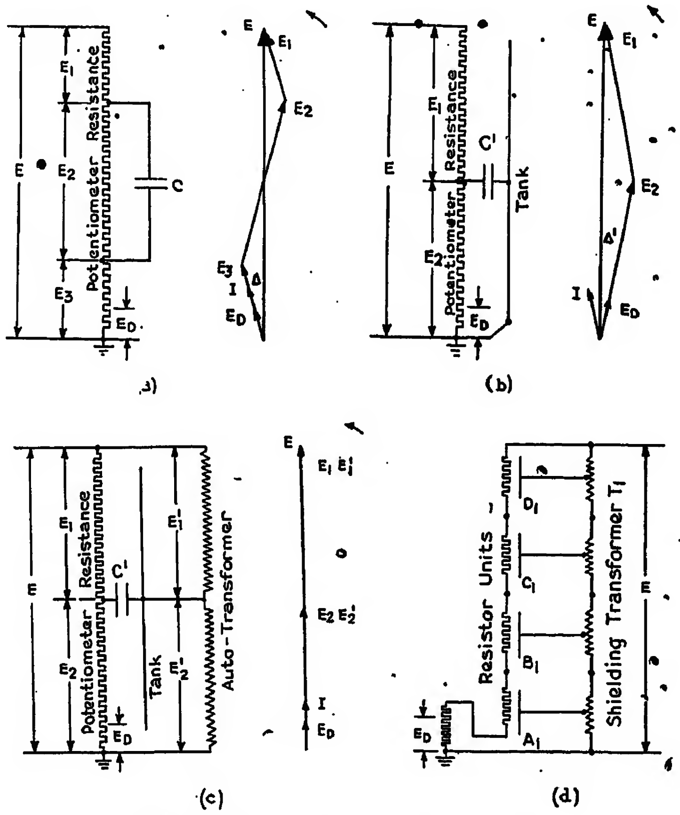


Fig. 2—Effects of Capacitance

(a) "Internal" capacitance between sections
(b) "External" capacitance to tank (ground)
(c) Elimination of effect of (b) by means of an auto-transformer
(d) Schematic arrangement of 44-kv., Group No. 1

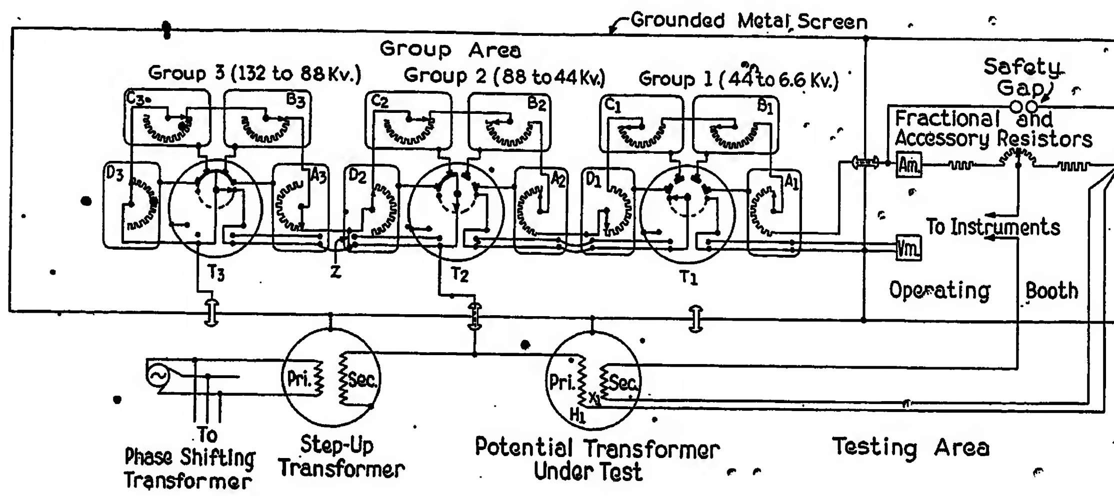
The potentiometer is shown schematically in Fig. 3A and B and directly in Figs. 6 and 7. The three 44-kv. series operating groups, each consisting of four 100,000-ohm resistor units and one shielding transformer, occupy about 380 sq. ft. (42 ft. by 9 ft.) of floor space and have a maximum height of about 12 ft., 3 ft. of which is due to the Herkolite insulating cylinders. The group area contains about 900 sq. ft. (52 ft. by 17.5 ft.); part of the grounded wire mesh which acts as an electrostatic screen for the groups is buried under the floor, while the remainder forms a fence 20 ft. high on the four sides of the area. The supply voltage is brought in from the

3. L. T. Robinson, *Loc. cit.*

testing area through high-voltage bushings. The metal and glass operating booth is about 16 ft. square and 8 ft. high. It contains the fractional and accessory resistances and all instruments and control equipment. Approved safety devices are used wherever necessary.

Resistors. The potentiometer has a total resistance of 1,200,000 ohms and is rated at 0.11 ampere. The resistance is divided into three 400,000-ohm operating groups, which are subdivided into four 100,000-ohm units. From the construction standpoint the 100,000-ohm interchangeable units are basic; they are made up of ten 10,000-ohm sections, which are in turn made up of twelve 833.3-ohm tubes each; construction details are shown in Figs. 4 and 5. The arrangement and ratings are summarized in Table I. A more "Detailed Description," which includes the fractional (normal value-1000 ohms) and accessory resistance, is given under that title.

Shielding Transformers. The three interchangeable shielding transformers (one for each 44-kv. group) are rated as follows: 25 cycles, 75 kv-a., 50,000, 500/500 volts. (The maximum voltage rating for the three primary windings in series is 150 kv.) Since their function is to equalize the flux density and voltage distribution in the transformers when either two or three are operating in series the secondary and tertiary windings are considered as equalizing windings; the connections are indicated in Fig. 3A and B. Each transformer has eight primary taps and nine bushings, one of which supports the somewhat complicated tap switch. The four unit tanks are connected to four of the bushings and from them to the proper transformer taps by means of the switch and thus maintained at predetermined potentials.



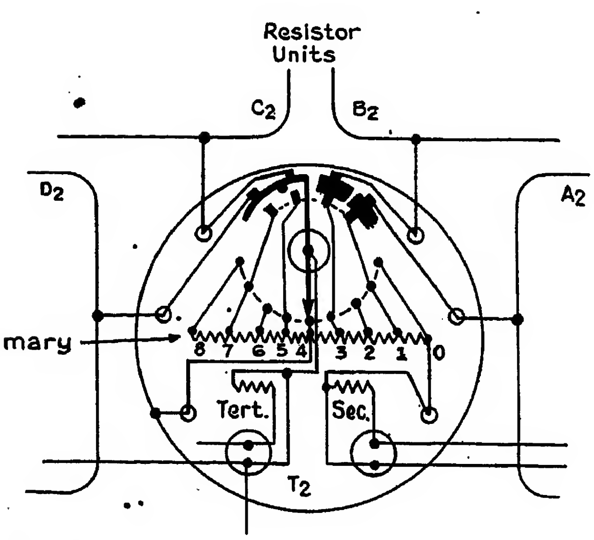


FIG. 3—132-KV. POTENTIOMETER—66-KV CONNECTION (SCHEMATIC)

(a) General outline

(b) Shielding transformer T_2 in Group No. 2

TABLE I
ARRANGEMENT AND RATINGS OF POTENTIOMETER RESISTORS

Item	Rating		Number Required	
	Ohms	Kv.	Per Step	Total
Tube........	833.3*	0.092	12 per Section	1440
Section......	10,000†	1.1	10 per Unit	120
Unit........	100,000	11	4 per Group	12
Group.......	400,000	44	3 for 132 kv.	3
3 Groups....	1,200,000	132		

*Approximate adjustment—rated at 0.11 ampere (9.09 ohms per volt) nominally, 0.125 ampere maximum.
†Adjustment correct within 0.02 per cent.

Operation. In operating, the total resistance used in each case is obtained by setting the tap switch on the 100 per cent tap in each of the 100,000-ohm resistor units up to the unit in which the final setting is made, all or only part of the resistance of this unit may be required—(ten equal steps are obtainable with the tap switch but only the 100 per cent and 50 per cent taps are, in general, used above Group No. 1); the tap switch

is set on the zero tap in each of the 100,000-ohm units beyond the unit in which the final setting is made. The correctness of the setting is then checked by a bridge measurement; this procedure is independent of the number of units used, since all units are connected in series; however, connection is made to the upper end of the highest group involved. The connections for 600,000 ohms or 66 kv. are indicated in Fig. 3A; the connection Z between the resistance and shielding transformer circuits is opened for the bridge measurement; the 0.2-ampere ammeter, Am, gives an approximate indication of the operating current.

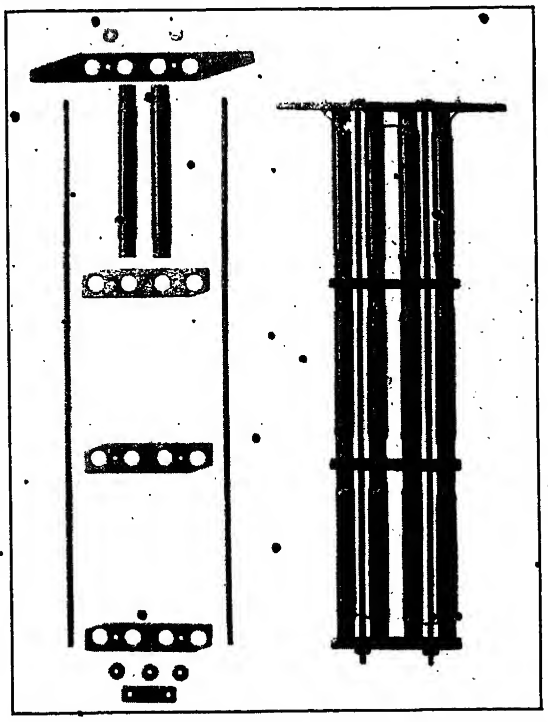


Fig. 4—Parts and Assembly of a 10,000-Ohm Resistor Section

(Approximately 36 in. x 8 in): 833-ohm resistor tubes; insulating spacers, binders, and tie rods

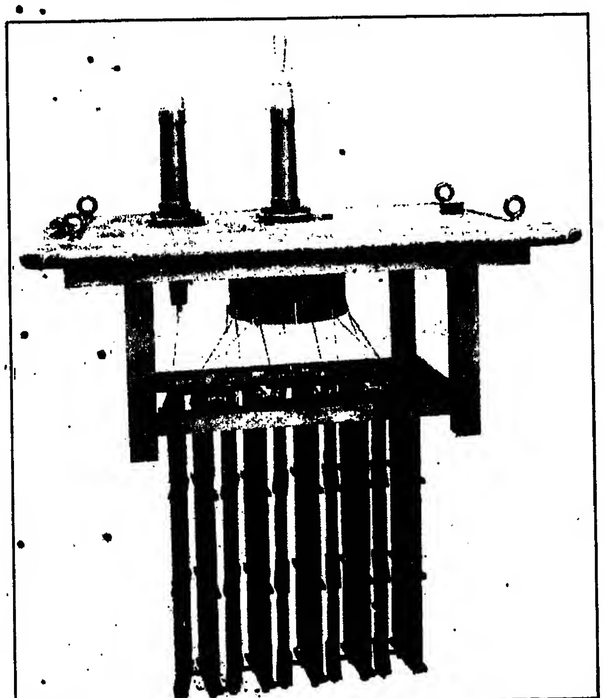


Fig. 5—100,000-Ohm Resistor Unit Untanked

With treated wood bushings cover (5 ft. x 3.5 ft.) and resistor supports; tap-changing switch; ten 10,000-Ohm "zigzag" resistor sections Welded steel tank (5.5 ft. deep) and two top shields (3.5 ft. high) not shown

The shielding transformers are excited magnetically only when one or more resistor units in their respective groups are in use. In Group No. 1, transformer T_1 is excited on tap No. 6 (nominally 33 kv.) for voltages between 6.6 and 30.8 kv. to obtain a minimum phase angle; taps No. 7 and 8 are used for higher voltages up to 44 kv. One lead between the tertiary of T_1 and the secondary of T_2 is opened, (similarly between T_2 and T_3); the other lead assures electrostatic excitation of group No. 2 (and No. 3) at line voltage; the tap switch of T_2 (and T_3) is set on the zero tap. Transformer T_2 is also excited magnetically for voltages between

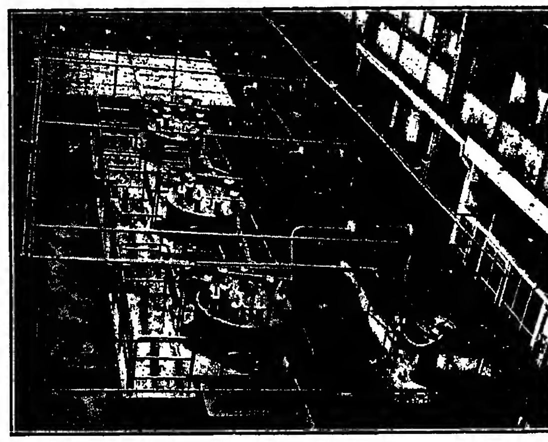


Fig. 6—132-Kv. Shielded Potentiometer: Three 44-Kv. Groups, Group Area and Screen; Operating Booth; Testing Area

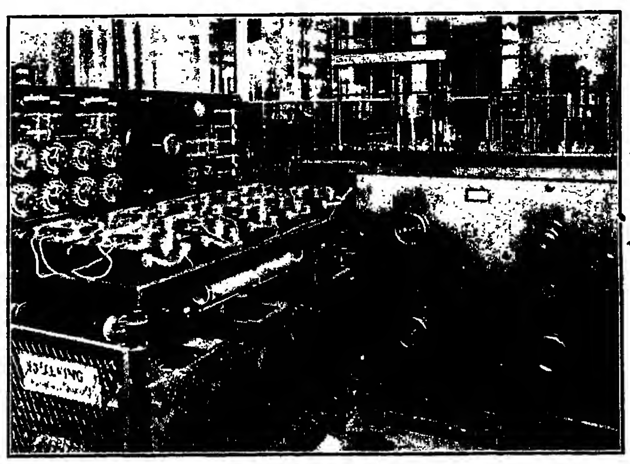


Fig. 7—Interior of Operating Booth: Operating Panel, Instruments, and Burdens; Pier for Reflecting Dynamometers; Field Control Panel

44 and 88 kv. and transformer T_3 for voltages between 88 and 132 kv.; the "highest" transformer tap used in either Group No. 2 or Group No. 3 has in general the same nominal voltage rating as the corresponding tap (100 per cent or 50 per cent only) of the "highest" resistor unit in use. The correctness of the shielding transformer tap setting is checked in all cases by comparing the reading of a 600-volt voltmeter, Vm, supplied from the secondary of T_1 with the reading of a 150-volt voltmeter supplied from the secondary of the potential transformer under test; the proper ratio between the two readings is predetermined for each marked or nominal potential transformer ratio. The connections for 66 kv. are indicated in Fig. 3A and B.

The distribution of voltage in the resistor units and in the shielding transformers for the 132-kv. connection is summarized in Table II. In this case the indicated current in the resistor circuit would be approximately 0.11 ampere, while the ratio between the secondary voltages of T_1 and of a 132-kv.:110-volt (1200:1 ratio) potential transformer under test would be approximately 440:110 or 4:1.

TABLE II
DISTRIBUTION OF VOLTAGE AT 132 KV. IN THE THREE 44-KV. GROUPS

Designation			Shielding Transformer Tap		
Group No.	Resis. Unit	Shield Trans.	No.	Kv.	Connected to
			0	0	Ground
			1	5.5	Tank of 1st Unit (A_1)
	A_1		2	11 *	—
			3	16.5	Tank of 2nd Unit (B_1)
1	B_1	T_1	4	22 *	—
			5	27.5	Tank of 3rd Unit (C_1)
	C_1		6	33 *	—
			7	38.5	Tank of 4th Unit (D_1)
	D_1		8	44 *	Tap No. 0 of T_2
			0	44	Tap No. 8 of T_1
			1	49.5	Tank of 5th Unit (A_2)
	A_2		2	55 *	—
			3	60.5	Tank of 6th Unit (B_2)
2	B_2	T_2	4	66 *	—
			5	71.5	Tank of 7th Unit (C_2)
	C_2		6	77 *	—
			7	82.5	Tank of 8th Unit (D_2)
	D_2		8	88 *	Tap No. 0 of T_3
			0	88	Tap No. 8 of T_2
			1	93.5	Tank of 9th Unit (A_3)
	A_3		2	99 *	—
			3	104.5	Tank of 10th Unit (B_3)
3	B_3	T_3	4	110 *	—
			5	115.5	Tank of 11th Unit (C_3)
	C_3		6	121 *	—
			7	126.5	Tank of 12th Unit (D_3)
	D_3		8	132 *	Line

*Voltage at corresponding resistor unit; the resistor and transformer circuits are joined at "Ground" and "Line" only.

After obtaining the proper settings as outlined, the desired secondary burden is set by means of dial switches and verified by instrument readings. The ratio and phase-angle readings are then taken as indicated under "Principles of Operation."

Detailed Description

The principal items described in the complete paper are: (1) 100,000-ohm resistor units, (2) fractional and accessory resistors, (3) operating panel and burdens, (4) shielding transformers, and (5) connections; a partial list of auxiliary equipment is included under (6).

Preliminary Work

An accuracy guarantee of within 0.1 per cent in ratio and within 5 minutes in phase angle means that the accuracy obtainable with the equipment under actual test conditions must be well within those limits in order to provide a reasonable "margin of safety" in the guarantee to cover slight differences between test and operating conditions. This in turn means that the sources of error in the equipment must be thoroughly investigated and that errors of the order of 0.01 per cent and 0.5′ are important.

An absolute accuracy better than within about 0.01 per cent cannot be expected for d-c. resistance values obtained by the best methods available; this limit must be somewhat increased for direct measurements with a high grade Wheatstone bridge. However, a much greater degree of comparative accuracy can be obtained by measuring the difference between two nearly equal resistors or between two nearly equal conditions of the same resistor. Therefore the latter method, which is also applicable to a-c. measurements, was used whenever possible in investigating the sources of error.

The following investigations or tests on the completed equipment, preliminary to using it for routine testing, are outlined in the complete paper: leakage, heating and capacitance of unit; characteristics of shielding transformers; effect of incorrect tank potentials, and of corona and capacitance on operation (special conditions); determination of phase-angle corrections.

Test Results

Representative ratio and phase angle results obtained to date with the new potentiometer are not included as it is not the purpose of the paper to discuss the characteristics of potential transformers. It will be evident, also, that a tabulation of test results, although undoubtedly of interest in that connection, is not necessary to demonstrate the soundness of the general proposition that all potential transformers should be tested for accuracy at full rated voltage; this procedure is now possible up to 150 kv. maximum at from 25 to 60 cycles.

Acknowledgment

The development, design, construction, and testing of a previously untried combination of equipment of such magnitude, to operate under conditions for which few useful data were available, would have been impossible without the cooperation and the suggestions of a large number of individuals.[4] Their assistance is greatly appreciated and the author regrets that a more direct acknowledgment is not possible here. It is a pleasure, however, to acknowledge particularly the assistance of Mr. C. W. LaPierre.

4. Principally in the General Engineering Laboratory at Schenectady, in the Pittsfield Works Laboratory, and the General Transformer Engineering Department at Pittsfield.

ILLUMINATION ITEMS

Submitted by

The Committee on Production and Application of Light

THE CENTER FIXTURE IN RESIDENCE LIGHTING

By Helen G. McKinlay*

To prescribe as a doctor may for the cure of an evil, with a reasonable assurance that at least the medicine will be given a trial, would be delightful to those planning the lighting for the homes of today.

Unfortunately, however, many people revolt against the cures recommended to overcome their lighting evils. Indisputably light from a center ceiling fixture will provide one of the most effective cures for inefficient "general" lighting in a room. Also, invariably when such suggestion is made the reaction against it, particularly by women, is "I don't like a center fixture." She doesn't say, "I don't like light in the center of a room," although many of us are apt to misinterpret her remark to mean that. What she really dislikes *is* the fixture! What price lighting!!

Many of us concede that overhead lighting brings about the best results in illumination and in lighting results, yet recognize that the medium through which it is achieved has indeed room for improvement.

The woman usually thinks of the lighting of her home in terms of the appearance of the fixture; she uses this as her standard simply because she hasn't given any thought to lighting as a science, nor considered its results if correctly applied. And as a consequence, when ceiling fixtures are suggested, she pictures that unattractive fixture,—an atrocity contemporaneous with the building of the last home in which she lived in which there was a ceiling fixture, and even some of the newer ones which are not departures from their antecedents.

With a better understanding of lighted effect, women will want center lighting on merit, but never will they accept it so long as it must be had at a sacrifice in the appearance of the room, nor until more pleasing fixtures are to be had.

Happily not all center fixtures are unattractive. And thanks to those manufacturers who have made good looking ones it is not a difficult problem to "sell" women on center lighting. They are quick to recognize the merit of central light from overhead when light is desired throughout the entire room, if it may be acquired through an unobstrusive fixture; they are rather intrigued with the fact too that by use of a center fixture instead of wall brackets, and plenty of outlets to connect their table and floor lamps, they may provide without sacrifice of light for their over-indulged "indoor sport" of rearranging the furniture in their rooms.

Homelighting must be sold to women. And women think of homelighting largely in terms of table and floor lamps. Fixtures mean little more to the average woman than the radiators or other permanent impersonal household accessories. But if fixtures are made more pleasing to the woman's eye in appearance, and of course supervised by an engineer's eye for proper construction in design, a firmer foundation upon which to build better homelighting will be established and more readily accepted.

*Edison Lamp Works of General Electric Company, Harrison, N. J.

TRAFFIC CONTROL

By W. T. Dempsey*

The new Code for Standardization of Street Traffic Signs, Signals and Markings built up by a Sectional Committee wherein the American Institute of Electrical Engineers was represented has now been completed. It has been accepted by the American Engineering Council which participated during the past several years in the national conferences on street and highway safety inaugurated by Herbert Hoover when Secretary of Commerce. He cystallized consideration of the subject in a national conference on street and highway safety, in an effort to minimize the possibility of accidents and reduce the numerous loss of life and injuries resulting from accidents on the public streets and highways throughout the country. Surveys were made in 35 states and returns analyzed were collected in more than 100 cities and it is believed that the returns covering all conditions and methods of traffic control and regulation will show that this survey has been of great benefit. The final report of the Committee is now in circulation throughout the country by the American Engineering Council and efforts are being made to have the Standard Code inaugurated into laws in every state in the Union to standardize devices of every description for the regulation of traffic and safety on the public highways.

Definite recommendations have been made to the effect that roadway signs installed for the safety of night driving, including important directional signs, be adequately illuminated. In fact the proper illumination of precautionary road signs is placed first in order of importance for safety on the highways for night driving. They should be visible for a distance of 100 ft.

Considerable space is devoted in the report to a consideration of the types of street traffic control signals which, of course, are generally operated by means of electrical devices, relays, various types of lenses and control circuits. As a general thing such regulating signals are controlled by means of synchronous motors. However, the system of remote control using pilot wires permits a very flexible form of operation. Normally the control of traffic of an entire City is operated from one central point. Under extraordinary traffic conditions at a particular place on a certain thoroughfare this system permits the control to be sectionallized as may be necessary to handle that particular part of the thoroughfare independently of the traffic regulating devices in other areas.

*Supt. Service Maintenance & City Lighting Service, New York Edison Company.

Another very commendable and noteworthy economy in the regulation of traffic by means of several types of electrically operated devices now on the market, is the releasing of police officers from this form of duty and permitting them to devote their time to real police work. These systems of control also eliminate the officer from the hazardous condition of directing traffic in the center of congested roadways, a step in the interests of safety.

ADVANCES IN INDUSTRIAL LIGHTING PRACTISE

By A. D. Bell*

The better types of industrial lighting installations today are characterized especially by two things; much higher levels of intensity, and reflecting equipment better suited to individual lighting problems so that glare is practically eliminated.

Higher levels of artificial illumination have gradually come into greater use largely on account of a realization on the part of the industrial plants of the several advantages to be gained through such illumination. The activities, first of lamp and reflector manufacturers and then, more recently, those of central stations, are convincing the industrial owners or managers of the value of proper artificial illumination by means of actual demonstrations and tests. Increasing efficiencies of light production and economic considerations, such as a lowering of electrical current rates and cheaper incandescent electric lamps, have likewise played a large part in this movement. Electric light is now so cheap that it can be used freely to attain the manifold benefits that it alone can produce.

Today we find foot-candle levels of 20, 40, 50 and higher, yet a decade ago 5 foot-candles was considered excellent for artificial lighting. Present levels when compared with those of natural sunlight (running into the thousands of foot-candles) are indeed puny, but if we look on the other hand at the general level of but a few years ago we can see that we are making real progress. However, we seem to be as far now from the saturation point in lighting as we were ten years ago because our objective is ever advancing.

In the field of industrial lighting equipment the changes have been many and varied. Types and varieties intended for the earlier types of incandescent lamps became obsolete with the advent of the present day lamps which have a different light distribution, different physical dimensions and a much higher brightness. This required new designs on the part of reflector manufacturers and as a result today we have a variety of reflectors made of different materials and suited to different conditions of use. In industrial service those made of enameled steel seem to predominate, largely on account of their efficiency, durability and ease of cleaning, with glass reflectors coming next in order. The glass equipment in both the prismatic and mirrored types find considerable application and are, too, very satisfactory. Other metal reflectors are also made, those in aluminum finish probably being the outstanding ones. Tin reflectors, coated with paint, are still used but there has been a decided trend toward the use of the better equipment which, though initially more costly, lasts much longer and is more satisfactory in the long run.

Of the more recent reflector developments we find several which might well be mentioned. In the vapor-proof class, reflectors have been brought out which fill a long standing need as they are not only truly vapor-proof but will actually stand up under acid fumes as well. For light directing and distributing qualities they are similar to the ordinary varieties.

To keep up with the trend toward higher intensities of illumination there are now available reflectors which will take the larger sizes of incandescent lamps. The Glassteel Diffuser is made in the 750- and 1000-watt size and both prismatic and mirrored glass reflectors for high mounting are obtainable in the 1000- and 1500-watt sizes. It is, of course, extremely important that glare be avoided and the new reflectors have been designed with this in mind.

For high intensities of illumination on small areas, and for the lighting of surfaces such as those of automobile bodies in the process of being finished, there have been put on the market concentrating types of reflectors which are particularly well adapted to this sort of work.

So much depends upon artificial illumination today in practically all our industrial enterprises that when we find marked improvements and developments in equipment it is an encouraging sign and indicates that the reflecting equipment is keeping pace with the demands of industry. When we note, too, that continuously higher levels of illumination are being successfully applied we can readily conclude that this field of electrical application is at last receiving due attention and that it holds almost unlimited possibilities for future growth.

*Edison Lamp Works of General Electric Company, Harrison, N. J.

PURCHASED POWER FOR RAILWAYS

In a recent address before the Boston Chamber of Commerce, President Atterbury, of the Pennsylvania Railroad strongly indorsed the purchase of electrical power for the use of electrified railroads rather than entering the power business for supplying their own properties. Speaking of the magnitude of the work of changing the motive power of the railroad, he said:

"We worked out a jointly owned power-plant scheme with the United Gas Improvement Company and the Philadelphia Electric Company but decided not to go into it. Why should we enter the power business? We have no warrant to go into that business which is an industry by itself. By the time we are ready to use it we shall be buying power cheaper than we can make it ourselves and thereby saving a capital investment of from $20,000,000 to $30,000,000 over a great number of years."

INSTITUTE AND RELATED ACTIVITIES

The Dallas Regional Meeting

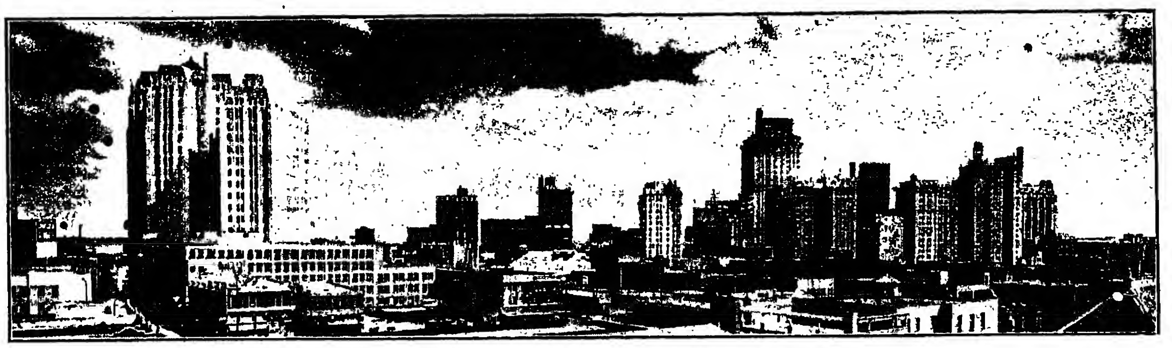
Engineering topics of live interest are on the program of the Regional Meeting of the South West District of the Institute in Dallas, Texas, May 7-9. Headquarters will be in the Adolphus Hotel. Four technical sessions are planned and there will also be two student sessions. Inspection trips, a most interesting lecture, a dinner-dance, etc., are other attractive events on the program.

Engineering Papers

A-c. networks, bare-wire distribution, interconnection, lightning research, and effect of lightning on transformers, reclosing high-voltage circuits, remote metering, oil pipe line electrification, electrical features of waterworks and lighting of flying fields and airways, are among the subjects which will be covered in the papers to be presented.

Student Meetings

Two student sessions will be held on the afternoon of May 7 and the morning of May 8, respectively. Student activities will be discussed and ten papers will be presented by students. A prize cup will be awarded for the best paper. All members are invited to attend these student sessions.



The Skyline of Industrial Dallas

Inspection Trips

A number of trips have been arranged to points of interest in and near Dallas. These are scheduled for 2:00 p. m., May 8, and the points which may be visited are as follows:

(a) Dallas Power & Light Company generating station

(b) Southwestern Bell Telephone Company dial and toll equipment

(c) Dallas Power & Light Company underground distribution system

(d) Other places, such as—refineries, cement plant, textile mill, stocking factory, cotton-oil mill, Trinity River Reclamation Project, Trinidad Electric Generating Station using powdered lignite, Western Union Plant, packing house, Proctor & Gamble Plant, flour mill, structural steel fabricating plant, and many other points of interest, can be inspected on request.

Lectures with Demonstrations

A most unusual and attractive lecture, supplemented by novel demonstrations will be given on the evening of May 7 by S. P. Grace of the Bell Telephone Laboratories, Inc. The title of this talk will be *Science and Research in Telephone Development.* Ladies, as well as men, will find this very enjoyable.

Entertainment

A dinner-dance on the evening of May 9, and provisions for playing golf are the chief entertainment features.

For the ladies, in addition to the entertainment already mentioned, there will be luncheons, drives, bridge, shopping tours, etc.

Reduced Railroad Rates

Reduced fares on the certificate plan have been arranged with the Southwestern Passenger Association. The special rate applies in full to all who purchase tickets in the Southwestern territory. Those who attend from the East may also benefit by the rate if they buy straight tickets to any point in the State of Arkansas, Kansas, Missouri, Oklahoma and Texas, and Memphis, Tennessee, and then re-buy from this point to Dallas.

Under this plan a certificate should be obtained when the ticket to Dallas is purchased. This certificate should be deposited at the registration desk at the meeting and if 100 certificates are deposited, return tickets may be purchased at one-half the regular fare. The same route must be followed in returning as used in going to Cincinnati.

Tickets will be sold from May 3 to May 9 and the latest return date is May 13.

Everyone should get a certificate whether he will use it or not. Doing this will help others to take advantage of the reduced fare which may result in considerable saving to those coming long distances.

Register in Advance

By registering in advance by mail, members will help the local committees in making plans.

At the meeting a registration fee of one dollar will be charged. Students and ladies will be exempt from this fee.

Hotel Reservations

Hotel reservations should be made by communicating directly with the management of the hotel. Rates for the headquarters hotel, the Adolphus, and for other nearby hotels are given below. A special rate for students of 75c. per day has been made by the management of the Adolphus Hotel.

HOTEL ROOM RATES

Name	Without bath		With bath	
	Single	Double	Single	Double
Adolphus			$2.00–6.00	$3.50–8.00
Baker			2.00–5.00	4.00–7.00
Jefferson	$2.00	$3.00	3.00	5.00
Hilton	1.50–1.75	2.75	2.00–3.00	3.50–6.00
Scott			2.00–2.50	4.00–5.00
Sanger Apts			2.00–2.50	5.00
Mayfair			2.00–2.50	4.00–5.00

Committees

The Regional Meeting Committee of the Southwest District is as follows: B. D. Hull, Chairman, Vice-President South West

District; A. E. Allen, Secretary; L. T. Blaisdell, C. V. Bullen, B. J. George, W. C. Looney, G. A. Mills, C. P. Potter, G. C. Shaad, and J. B. Thomas.

The officers of the other committees are: *Local Committee*—G. A. Mills, Chairman; A. Chetham-Strode, Secretary; *Meetings and Papers*—J. B. Thomas, Chairman; *Entertainment & Reception*—L. T. Blaisdell, Chairman; *Transportation & Inspection*—W. C. Looney, Chairman; *Hotels & Registration*—E. L. Glander, Chairman; *Attendance & Publicity*—T. C. Ruhling, Chairman; *Finance Committee*—C. G. Matthews, Chairman; *Student Activities*—G. C. Shaad, Chairman.

PAPERS BY STUDENT MEMBERS

Evaluation of Physical Property of Distribution Systems, T. E. Peters, University of Arkansas.

Piezoelectric Oscillators, Leroy Moffott, Jr., University of Oklahoma.

Frequency Stability of Split-Anode Magnetron Oscillators, Norvel Douglas, University of Kansas.

A General Network Theorem, L. R. Brown, University of Texas.

The Effect of Terminating Impedances on the Characteristics of Filters, M. J. Miller, Washington University.

8:00 p. m. Address "Science and Research in Telephone Development," S. P. Grace, Bell Telephone Laboratories, Inc.

WEDNESDAY, MAY 8

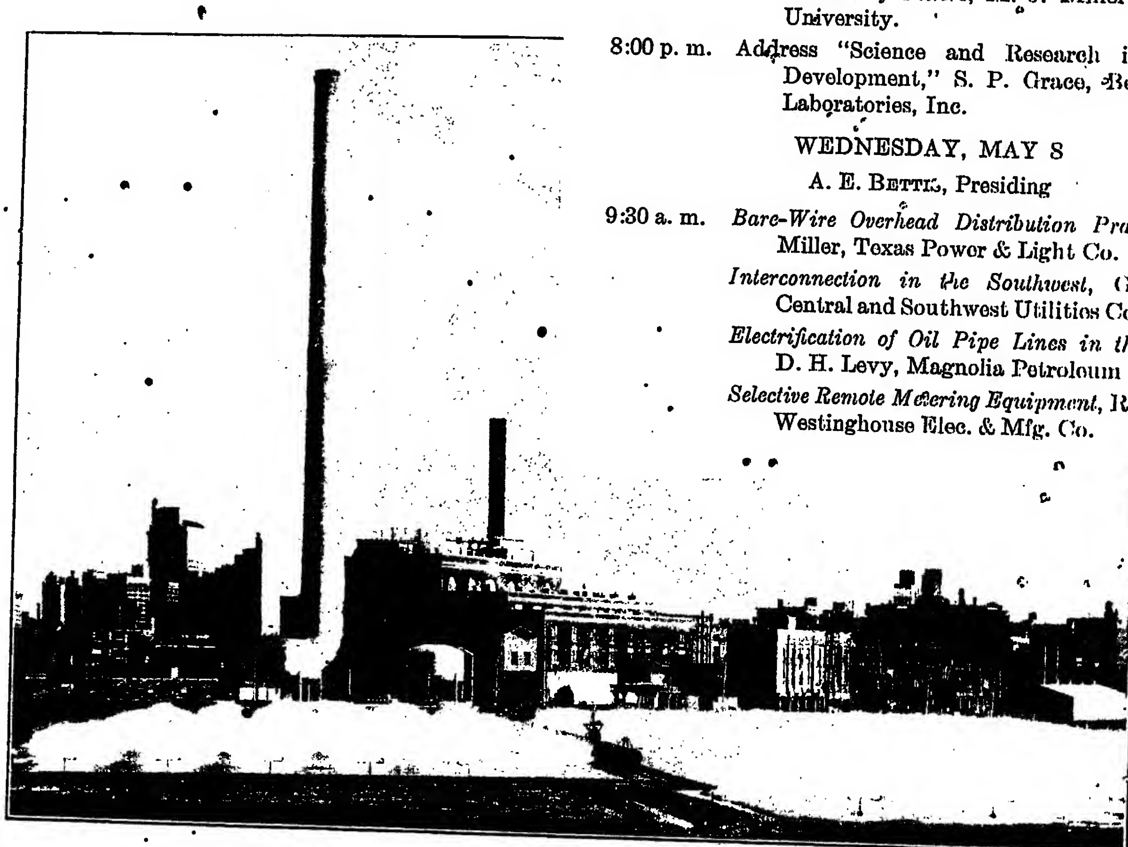
A. E. BETTIS, Presiding

9:30 a. m. *Bare-Wire Overhead Distribution Practise*, M. C. Miller, Texas Power & Light Co.

Interconnection in the Southwest, G. A. Mills, Central and Southwest Utilities Co.

Electrification of Oil Pipe Lines in the Southwest, D. H. Levy, Magnolia Petroleum Company.

Selective Remote Metering Equipment, R. J. Wensley, Westinghouse Elec. & Mfg. Co.



GENERATING PLANT OF THE DALLAS POWER AND LIGHT COMPANY

PROGRAM OF DALLAS REGIONAL MEETING

TUESDAY, MAY 7

9:00 a. m. Registration.

10:00 a. m. Opening of Convention. B. D. Hull, Vice-President, 7th Geographical District, A. I. E. E. presiding.

Address of Welcome.

Power Session

G. A. MILLS, presiding

Developments in Network Systems and Equipment, T. J. Brosman and Ralph Kelly, Westinghouse Elec. & Mfg. Co.

Standard Voltage A-C. Network, John Oram, Dallas Power & Light Co.

Automatic Reclosing of High-Voltage Circuits, E. W. Robinson and S. J. Spurgeon, Alabama Power Co.

12:30 p. m. Joint Luncheon with Dallas Electric Club.

2:00 p. m. Joint Meeting Student Branches and Sections. G. C. Shaad, Chairman.

Remarks, R. F. Schuchardt, President, A. I. E. E.

Student Session

9:30 a. m. Opening Remarks, B. D. Hull, Vice-President, 7th Geographical District, A. I. E. E.

Student Activities. H. H. Henline, Assistant National Secretary, A. I. E. E.

General Discussion.

PAPERS BY STUDENTS

A Method of Measuring Surface Iron Losses, H. E. Gove and R. A. Folt, University of Missouri.

Positive Sense: Its Appliaction to Vector Diagrams T. W. Beams, Texas A. & M. College.

Performance of Standard Transformers Connected as Auto-Transformers, J. J. Loving and G. R. Redden, Texas A. & M. College.

Supervision of Gas, Electric and Water Meters in Texas, W. E. Henrichson, University of Texas.

A Universal Deficiency Compensating Amplifier, J. E. Peek, Oklahoma A. & M. College.

2:00 p. m. Inspection Trips.

7:00 p. m. Dinner-Dance.

THURSDAY, MAY 9

Morning Session

J. B. THOMAS, Presiding

9:30 a. m. *Progress in Lightning Research*, F. W. Peek, Jr., General Electric Co.

Lightning Studies of Transformers by the Cathode Ray Oscillograph, F. F. Brand and K. K. Palueff, General Electric Co.

Flying-Field and Airway Lighting, R. Odgen, U. S. Army.

Electrical Features of the New Kansas City Water Works Plant, A. L. Maillard, Consulting Engineer.

A VIEW OF ONE OF THE SIXTEEN GOLF COURSES IN DALLAS

Afternoon Session

W. O. PENNELL, Presiding

2:00 p. m. *Meeting Long-Distance Telephone Problems in the Southwest*, H. R. Fritz and H. P. Lawther, Southwestern Bell Telephone Co.

Railway Train Signal Practise, P. M. Gault, Missouri-Pacific System.

Telephone Transmission Networks, T. E. Shea and C. E. Lane, Bell Telephone Laboratories.

Program Transmission over Telephone Circuits for National Broadcasting, F. A. Cowan, American Telephone and Telegraph Co.

The 1929 Summer Convention

A Summer Convention which promises to equal any past Institute convention in excellence of technical discussion and in pleasurable entertainment is being planned for this year's meeting at Swampscott, Mass., June 24 to 28. The New Ocean House will be headquarters for the meeting. During the past six years, the progress of the electrical development in New England has made remarkable strides; the electrification of industry has created a multiplicity of opportunities for the study of advanced and diversified practise in the application of motors and control, modern lighting facilities, and industrial heating. Interconnection of tidewater steam plants and interior hydro plants by transmission lines has established a network of power supply; a pioneer rotary condenser operating in an atmosphere of hydrogen is in service in Pawtucket; the radio broadcasting stations, universities, colleges, and communication companies are preparing for engineering and historic trips which this richly developed region affords. In the technical program planned by the Convention Committee such subjects as distribution, electric transportation, electrical machinery, shielding in electrical measurements and others of these topics will be presented.

Reviews of developments in all phases of electricity will be covered in the annual reports of the Institute Technical Committees. Several worth while inspection trips as well as sight seeing trips are being arranged.

Annual conferences of Officers, Section Delegates, and Branch Delegates will be another important part of the meeting to which the first day will be devoted.

Plans for entertainment and recreation are being formulated by a large and enthusiastic convention committee. These will include tournaments for golf and tennis, a dinner, a reception, dancing, and a day's trip to York Beach.

Further details of the Convention will be published in succeeding issues of the JOURNAL.

Radio Engineers to Meet April 3

The New York Meeting of the Institute of Radio Engineers to be held on the third of April in the Engineering Societies Building will have on its program the following interesting and instructive papers:

Broadcast Stations, by Henry L. Bogardus and Charles T. Manning (to be presented by Mr. Bogardus); The Testing of Piezo Oscillators for Broadcasting Stations, by E. L. Hall; Observations on Modes of Vibration and Temperature Coefficients of Quartz Plates, by F. R. Lack; A High Precision Standard of Frequency, by W. A. Marrison; A Convenient Method for Referring Secondary Frequency Standards to a Standard Time Interval, by L. M. Hull and James K. Clapp (to be presented by Mr. Clapp); Frequency Measurement, by S. Jimbo (to be presented by Doctor Walter G. Cady); and The Precision Measurement of Time, by Alfred L. Loomis.

The American Welding Society Annual Meeting

With the opening session April 24, and continuing with other technical sessions through the morning of the 26th of the month, the program of the American Welding Society's Annual Meeting to be held in the Engineering Societies Building, will include interesting papers on the various applications and phases of welding, closing with a review of progress made to date and a discussion of future committee activities.

Colloquium on Power-Circuit Analysis at M. I. T.

From June 10 to June 22 inclusive, there will be conducted at the Massachusetts Institute of Technology by its Electrical Engineering Department aided by power transmission engineers and operators from various sections of the country, a Colloquium on Power-Circuit Analysis with special reference to the behavior of machinery and transmission line stability. Registration on June 10 will be at 10:00 a. m., with technical session in the afternoon under the auspices of the Electrical Engineering Staff of M. I. T.; Tuesday's sessions will be led by the General Electric Company and the Westinghouse Electric & Mfg. Co., the technical session on Wednesday, the 12th, by an eastern or midwestern company, and on the following day there will be another technical session followed by a general discussion of points raised at the four preceding sessions. Each day's technical program takes up some subject of interest and importance to the profession. On Wednesday, June 19th, there will be a demonstration of the integraph and the calculating table in the Electrical Research Laboratories of the institute. A final announcement, giving other details and the names of the various speakers, will be sent out in May. Inquiries may be addressed to Professor G. C. Dahl, who is director of the Colloquium.

Twelfth Exposition of Chemical Industries

With the growing importance of modern chemical engineering to almost every field of industry, interest in the Twelfth Exposition of Chemical Industries to be held in Grand Central Palace the week of May 6th is bound to be general. One important feature will be Export Day, May 9th, when the exhibitors will be especially prepared to meet foreign guests and discuss with them their products and problems. Student courses are also being arranged under the direction of Professor W. T. Read, of Texas Technological College, who will place the attendant lectures with competent speakers.

A. I. E. E. STANDARDS

Test Codes for Electrical Machines

In the Journal for January the proposal to establish test codes for electrical apparatus was mentioned. A further step has now been taken in this connection as the Standards Committee of the Institute at its meeting of February 27th directed that a committee should be appointed to make a survey of the situation. This action was taken following a report from the Electrical Machinery Committee expressing an opinion that the development of such electrical test codes would be a very valuable and desirable activity of the Institute. Chairman Newbury of the Standards Committee has appointed the special committee with the following personnel: F. M. Farmer, chairman and W. J. Foster, A. M. MacCutcheon, W. I. Slichter and E. C. Stone. This committee will report on the desirability, scope, general methods of work, probable expense and time involved in preparation of such codes.

In a general way what is meant by a test code for electrical apparatus can be most easily determined by reference to the Test Codes developed by the American Society of Mechanical Engineers, such as steam boilers, reciprocating engines, pumps, condensing apparatus, etc. The purpose of electrical test codes would be to provide standard directions in detail for conducting and reporting acceptance and performance tests of electrical machinery and apparatus. It is realized by the Standards Committee that this proposed undertaking is a long and expensive one and comments on its value are being solicited from men throughout the electrical field. If those interested will send in their comments it will be greatly appreciated. Address H. E. Farrer, Secretary Standards Committee, A. I. E. E., 33 West 39th St., New York, N. Y.

Values of A-C. Test Voltage for Household Devices Cancelled

In the 1922 Edition of the A. I. E. E. Standards, Rule 16,000—"Values of A-C. Test Voltage for Household Devices"—specifies a test of 500 volts at operating temperature for heating devices taking not over 660 watts and intended solely for operation on supply currents not exceeding 275 volts. This rule has never been replaced in the work of revision and in accordance with Standards procedure is therefore still applicable. In the opinion of the Standards Committee, because of the low value of test specified, the rule should be cancelled. An action recommending such action to the Board of Directors was taken and will come before the Board at its meeting of March 21.

Standards for Heating Devices

Following the cancellation of Rule 16,000, mentioned previously, the Standards Committee directed that a committee be appointed to investigate the field of both household and industrial electrical heating devices. The committee will report whether the Institute should undertake to develop such standards.

Report on Graphical Symbols for Radio

Action was taken by the Standards Committee on February 27th recommending the publication as a Report on A. I. E. E. Standards of the report of the subcommittee of the Sectional Committee on Radio on "Graphical Symbols for Radio." This report is now in preparation and will be available shortly.

Bureau of Standards to Publish all Letter Symbols in Single Volume

In view of the usefulness of a single volume containing all the recently approved standards for letter symbols the Bureau of Standards on receipt of approval by the sponsors of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations has agreed to publish such a volume. Individual pamphlets covering most of the symbols so far adopted can be purchased from Institute headquarters.

Engineering Fellowship at University of Wisconsin

The following fellowships in Engineering are available at the University of Wisconsin for the year 1929-30:

Three University Fellowships,—stipend $750 per year: available to graduates of engineering colleges of recognized standing, and intended to promote graduate study. Holders of these fellowships are expected to complete their work for the Master of Science degree in one year. A small amount of assigned work may be required.

Two Research Fellowships:—appointments for a period of two years, subject to satisfactory service; salary for the first year, $900; and for second year, $1100.—Appointees for these fellowships established to promote research work in the College of Engineering, are expected to devote not less than one-half their time to assigned research. There will be opportunity to complete the requirements for the Master of Science degree within the two-year period; under favorable conditions at the end of one year. Candidates must be graduates of Engineering Colleges of recognized standing, and preferably should have had one or two years of graduate study, teaching, or engineering experience. The period of service will be the usual academic year, including the short vacations.

Appointments to be made April 25; applications should be received not later than April 15.

Application blanks may be obtained from Dean F. E. Turneaure, College of Mechanics and Engineering, or Dean C. S. Slichter, Graduate School, University of Wisconsin, Madison, Wisconsin.

Winter Convention Discussion

A summarized report of the discussion of the technical papers presented at the Winter Convention, January 28 to February 1, is given in the following paragraphs. Complete reports of the discussion will be published in the TRANSACTIONS. In the following report the titles of the papers in each session are given immediately preceding the corresponding discussion.

SESSION ON DIELECTRICS AND ELECTROPHYSICS

Anomalous Conduction as a Cause of Dielectric Absorption, J. B. Whitehead and R. H. Marvin, Johns Hopkins University.

Power Factor and Dielectric Constant in Viscous Liquid Dielectrics, D. W. Kitchin, Simplex Wire & Cable Co.

Corona Ellipses, V. Karapetoff, Cornell University.

Flux Linkages and Electromagnetic Induction, L. V. Bewley, General Electric Company.

In the discussion E. R. Thomas suggested that Maxwell's theory of the equivalent circuit might be applicable to the common dielectrics, explaining his contention by test results on laboratory and commercial condensers. F. M. Clark said that he has concluded that high absorption and high dielectric loss in oils must be due in part at least to the presence of impurities. He agreed that the dipole theory of Debye gives as satisfactory explanation as any of dielectric action. G. M. J. Mackay suggested that in the determination of the relation between d-c. and a-c. effects it would be helpful to study geometrically simple set-ups and to exaggerate the effects found in commercial materials. He said that until measurements have been made on purified materials he hesitates to believe that the losses involved in molecular orientation are mainly responsible for the dielectric loss found in engineering practise. A. Nyman asked if experience has shown that absorption actually affects the life of a dielectric. J. B. Whitehead stated that he found nothing that indicates that dielectric loss at low frequencies can be explained by Debye's theory, though at high frequencies this theory explains the action as stated by Mr. Kitchin. Mr. Kitchin agreed that in liquid materials at low frequencies, such as 60 cycles, the dipole loss does account for the peak in the 60-cycle power factor curve. He disagreed with Mr. Clark's contention that impurities affected his results as he had used pure materials and checked the results in several ways.

SESSION ON CABLES

High-Tension Underground Cable Research and Development, G. B. Shanklin and G. M. Mackay, General Electric Company.

Some Problems in High-Voltage Cable Development, E. W. Davis and W. N. Eddy, Simplex Wire & Cable Co.

Ionization Studies in Paper-Insulated Cables—II, C. L. Dawes, H. H. Reichard and P. H. Humphries, Harvard Engineering School.

Reduction of Sheath Losses in Single-Conductor Cables, Herman Halperin and K. W. Miller, Commonwealth Edison Company.

Losses in Armored Single-Conductor Lead-Covered Cable, O. R. Schurig, H. P. Kuehni and F. H. Buller, General Electric Company.

M. T. Crawford in discussing the first paper pointed out that temperature changes have caused ordinary splicing sleeves to burst in cases where the cable insulation was loosely wrapped. He recommended that either splicing sleeves be made stronger or expansion chambers be provided. F. A. Brownell pointed out the improved performance which modern cables give. The maximum life obtained on five samples tested five years ago was 23 hr. at 192 volts per mil and 5 hr. at 224 volts per mil. At present, tests give 226 hr. at 202 volts per mil without failure and 95 hr. at 224 volts per mil. The tests leave the present cables free from wax and dendriditic designs except near the failure. Cables have been tested 25 hr. at 260 volts per mil with practically no temperature rise. In discussing oil-filled joints, Herman Halperin stated that his experience proved that oil does not migrate to any great distance from the joint. He disagreed with the recommendation to decrease temperature limits of present cables. T. F. Peterson stated that he believed that in cables for 600 to 1300 volts from 2 to 6 per cent of air is permissible.

In connection with the Dawes, Reichard, and Humphries paper, W. B. Kouwenhoven stated that the use of flat samples might have introduced errors as it is very difficult to prevent voids in such samples. He added that in his work a sealing compound of three parts beeswax and one part rosin had proved very satisfactory. J. B. Whitehead pointed out that with some kinds of paper at higher temperature the power factor decreases as the voltage is raised. In answer to Mr. Peterson's suggestion, Dr. Mackay admitted that gas may be present in cable without ionization if the pressure is high enough but stated that air is objectionable because it oxidizes the compound.

H. R. Searing stated that as triplex cables of the oil-filled type have been developed for operation at 66 kv. and below, he feels that these should be preferable to the single-conductor cable at these voltages on account of the poorer regulation resulting with the single-conductor cables. P. S. Creager mentioned some tests on single-conductor 26,000-volt cable, cross-bonded and grounded at every third length as in Fig. 2a of the Halperin and Miller paper. He found that under short-circuit conditions the voltage across the insulating joints was about 300. Mr. Miller stated that his company has not experienced difficulty with poor regulation or unbalanced loads among cables operating in parallel because the single-conductor lines are short and of equal length.

SESSION ON TRANSMISSION AND LIGHTNING

A Graphical Theory of Traveling Electric Waves between Parallel Conductors, V. Karapetoff, Cornell University.

Progress in Lightning Research in the Field and the Laboratory, F. W. Peek, Jr., General Electric Co.

1927 Lightning Experience on 132-Kv. Transmission Lines, Philip Sporn, American Gas & Electric Company.

Theoretical and Field Investigation of Lightning, C. L. Fortescue, A. L. Atherton and J. H. Cox, Westinghouse Electric & Manufacturing Company.

Protection of Transmission Lines from Interruption by Lightning, by 1927-28 Subcommittee of Power Transmission & Distribution Committee.

Following these papers, K. B. McEachron described tests he is making by applying artificial lightning surges to transmission lines. J. H. Cox said that he believed Mr. Peek claimed too strongly that lightning phenomena have been reduced to definite numerical values. J. J. Torok said he doubted Mr. Peek's contention that lightning energy can be dissipated within one span of a transmission line. C. F. Harding brought out the advantages of using a cathode ray oscillograph in lightning studies and briefly described a new instrument of this type developed at Purdue University. E. S. Lee described a cathode ray oscillograph of an actual lightning surge which was shown to be positive in polarity, unidirectional, reaching its maximum in 5 microseconds, decreasing to half value in 20 microseconds and to zero in 50 microseconds. Superimposed at the peak was a highly damped oscillation of 2,000,000 cycles. P. H. Thomas voiced the opinion that the rising front of the surge wave is the part due to lightning and that the length of tail depends altogether on the amount of line affected and its facility for dissipation. He suggested further that the resistance of tower footings is not important in the dissipation of surges as the reactance of lines and ground greatly predominates. Edward Beck pointed out that the cathode-ray oscillograph has shown that lightning surges do not have as steep fronts as formerly

thought and that a front of ¼ microsecond would be unusually steep. J. S. Mahan and M. G. Lloyd presented records of 248 companies showing the distribution of surge damages among different classes of station and line equipment.

Discussing Mr. Anderson's paper, F. C. Hanker pointed out the difference in purposes for which a-c. and d-c. circuit breakers are used. He questioned the widespread use of high-speed breakers in d-c. railway feeders. In answer to this, Mr. Anderson stated that for 1500-volt and 3000-volt d-c. feeders the high-speed breaker has distinct advantage and is practically a necessity.

In discussing the last three papers, P. H. Chase stated that the deion circuit breaker promises revolutionary advantageous changes in station design which will result from absence of oil and high speed of operation. S. M. Dean, Viele, R. C. Mason and C. A. Corney made similar comments. J. W. McNairy described briefly another type of airbreak breaker which he said utilizes a principle of deionization similar to that described in Mr. Slepian's paper. R. M. Spurck suggested the desirability of tests on the deion breaker in interrupting charging currents and exciting currents. In a written discussion, J. D. Hilliard claimed that neither oil throw nor an oil fire need accompany the interruption of an electric circuit by an oil circuit breaker. F. J. McKittrick asked if it is possible to have a circuit in which the voltage builds up faster than the rate of deionization. F. W. McNeill stated that the extension of the deion principle to 25,000-volt breakers bears considerable promise.

Answering Mr. Spurck's question, B. P. Baker stated that tests have indicated that the new breaker will open low currents quite satisfactorily. The time of interruption is longer on small currents but this time may be decreased by strengthening the blow-out field which, however, has not been thought necessary. In answering a question of Mr. Dean, he stated that use of a series disconnecting switch has been found unnecessary as safety requirements are met more economically by adding insulation to the breaker.

Session on Communication

Application of Radio in Aviation, J. H. Dellinger of U. S. Bureau of Standards.

Influence of Moisture and Electrolytes upon Textiles as Insulators, R. R. Williams and E. J. Murphy, Bell Telephone Laboratories.

Purified Textile Insulation for Telephone Central Office Wiring, H. H. Glenn and E. B. Wood, Bell Telephone Laboratories.

Vector Representation of Wave Filters, R. F. Mallina and O. Knacknuss, Victor Talking Machine Co.

William Fondiller in discussing the first two papers pointed out that formerly efforts had been made to increase the insulating strength of textiles by treatment with moisture-resisting compounds but that these treatments affected but slight improvement. The excellent results obtained by washing were due, he said, to applying the research point of view to the problem. E. B. Wood said the purified textile insulation might be valuable for use in tropical countries.

In answer to a question by H. W. Drake in connection with the paper by J. H. Dellinger, H. Diamond stated that it is sometimes difficult to get an airplane pilot to depend on indications of instruments rather than his visual observation.

Session on Induction Motors

The Condenser Motor, B. F. Bailey, University of Michigan.

The Fundamental Theory of the Capacitor Motor, H. C. Specht, Westinghouse Electric & Mfg. Co.

The Revolving-Field Theory of the Capacitor Motor, W. J. Morrill, General Electric Co.

Line-Start Induction Motors, C. J. Koch, General Electric Company.

Calculating No-Load Core Losses in Induction Motors, Thomas Spooner and C. W. Kincaid, Westinghouse Electric & Mfg. Company.

In discussing the first three papers, C. R. Boothby pointed out that the maximum torque of a capacitor motor is inversely proportional to the total resistance of the capacitor phase circuit. H. C. Louis asked if it is an inherent fault that the capacitor motor requires 30 to 50 per cent more starting circuit than repulsion motors. He asked also if condensers are made which will last in service. Answering this question A. Nyman stated that if large enough paper condensers are used, they will last for years. W. I. Schlicter said that reliable condensers are now being manufactured. In a written discussion, E. G. Michelsen and L. F. Hemphill stated that the capacitor motor is not inherently reversible but that its characteristics in this regard are dependent on the design, the value of external reactance being the predominating factor. H. C. Specht pointed out that claims should not be made that the capacitor motor is preferable where polyphase energy is available. P. H. Rutherford stated that he believed that when large production is obtained the cost of the capacitor motor will be very near that of the repulsion induction motor. W. J. Morrill said he thought the cost will be about 25 or 30 per cent higher for the capacitor motor than for another motor in the same competitive class.

Several of the speakers expressed the opinion that the present permissible starting currents allowed by the power companies are too low and A. M. MacCutcheon advanced the idea that possibly the time and the frequency of starting should be considered. F. E. Harrell commenting on Mr. Koch's paper claimed that it is questionable from the standpoint of manufacturing economy, that the double-cage motor is superior to the single-cage motor. C. W. Franklin pointed out that the power companies must require that starting does not give trouble to other customers, particularly on combined power and light circuits. For this reason he said incremental starting is desirable in some cases.

Session on Electrical Machinery

Insulations Tests of Electrical Machinery Before and After Being Placed in Service, C. M. Gilt, Brooklyn Edison Company, and B. L. Barns, Canadian General Electric Company.

Influence of Temperature on Large Commutator Operation, F. T Hague and G. W. Penney, Westinghouse Electric & Mfg. Company.

Effect of Transient Voltages on Power-Transformer Design, K. K. Palueff, General Electric Co.

Transient Analysis of A-C. Machines, Yu. H. Ku, Massachusetts Institute of Technology.

Two-Reaction Theory of Synchronous Machines—Part I, R. H. Park, General Electric Company.

J. S. Henderson in connection with the first paper claimed that if turbine generators must be dried out after installation space heaters should be used instead of short-circuit current in the generator windings. He also suggested tests shorter than one minute on installed apparatus. F. E. H. Mowbray disagreed with the maintenance tests proposed by the Gilt and Barns paper. He recommended a test to ground on one phase at a time with the other phases grounded, at 130 per cent of normal line voltage for 15 seconds. D. A. McKenzie advocated rigid adherence to A. I. E. E. Standards in testing newly installed generators. F. D. Newburg said he doubted that standards could be agreed upon for tests during service. W. F. Dawson cautioned that dust and dirt should be removed from windings before they are subjected to high-voltage tests. Several speakers agreed that standardization of tests immediately after installation is desirable but that periodic service tests cannot be standardized.

In discussing the Hague and Penney paper, C. R. Soderberg emphasized the great value of the brush-drop test for analyzing the mechanical behavior of commutators. C. L. Dawes enumerated some of the qualities required in commutator mica and discussed the effects of varying the amount of binder. F. D.

Newbury stated that in connection with commutators the A. I. E. E. Standards need revision so that the requirements will be based on mechanical tests rather than electrical. G. W. Penney pointed out further that the allowable temperature also depends on the mechanical construction of each commutator.

J. F. Peters pointed out the difficulty of equalizing voltage stresses in transformers by means of static shields as suggested in the paper by K. K. Palueff. F. W. Peek, Jr. spoke of the advantages of making a transformer oscillation-proof as is attempted in M. Palueff's design. He explained also that it is impossible to protect a transformer by installing an inductance in series with it, as the resulting voltage on the transformer windings may actually be increased by this arrangement in case of an impulse voltage on the line. V. M. Montsinger stated that the A. I. E. E. Rules for transformers on solidly grounded systems are not satisfactory. These rules specify that insulation should be tested at 2.73 times normal line voltage. Experience has shown, he said, that this practise is satisfactory in sections where lightning is not severe but is not satisfactory in severe lightning sections.

Session on Electrical Measurement of Non-Electrical Quantities

Magnetic Analysis of Materials, R. L. Sanford, U. S. Bureau of Standards.

Measurements of Flow by Use of Electrical Instruments, W. H. Pratt, General Electric Company.

Use of the Oscillograph for Measuring Non-Electrical Quantities, D. F. Miner and W. B. Batten, Westinghouse Electric & Mfg. Company.

Study of Noises in Electrical Apparatus, Thomas Spooner and J. P. Foltz, Westinghouse Electric & Mfg. Company.

Electrical Aids to Navigation, R. H. Marriott, Consulting Engineer.

Commenting on Mr. Sanford's paper, B. M. Smith mentioned a further useful application of magnetic analysis; namely, the determination of the chemical composition of magnetic materials. A. V. de Forest stated that he believed magnetic tests are more fundamental than mechanical tests.

In connection with the paper by Messrs. Miner and Batten, M. A. Rusher mentioned several additional mechanical measurements which can be made by means of the oscillograph, such as displacement, rotational speed, vibration, timing, sound-recording, etc. A. V. de Forest stated that a carbon pile has been developed which is very useful in measuring pressures and movements in connection an oscillograph. W. B. Kouwenhoven told of several medical uses of electrical measurements. T. B. Floyd and Perry Borden both told of the use of one oscillograph element in measuring more than one quantity. Mr. Borden citing a case when time, rotational speed and current were recorded in one curve. C. A. Mead outlined the use of the oscillograph in piano tuning. F. G. Graph mentioned its use in determining the extent of oil pools. E. S. Lee described the use of electrical measurements in determing the shaft horsepower on very large electrically driven ships.

Session on Instruments and Measurements

Telemetering, C. H. Linder, H. B. Rex, C. E. Stewart and A. S. Fitzgerald, General Electric Co.

Totalizing of Electric System Loads, P. M. Lincoln, Cornell University.

A New High-Accuracy Current Transformer, M. S. Wilson, General Electric Company.

132-Kv. Shielded Potentiometer for Determining the Accuracy of Potential Transformers, C. T. Weller, General Electric Company.

A Precision Regulator for Alternating Voltage, H. M. Stoller and J. R. Power, Bell Telephone Laboratories.

In discussing the first paper, S. C. Jacobi described the telemetering system of the Montaup Electric Company and outlined several advantages of the system.

In connection with Dr. Lincoln's paper, H. B. Brooks pointed out that where graphic records are not required other types of instruments than the potentiometer are satisfactory for indicating the voltages produced by the thermal converters. F. L. Lawton, D. A. McKenzie and A. R. Welds stated that the scheme of totalizing has been used extensively on their company's system with advantageous results. Bela Gati suggested the use of of barretter wires (having very small diameter) in the totalizing meter. He said this would reduce the time of response to about 0.0001 second. In answer to a question, Dr. Lincoln stated that there is no error in indication when the meter is operated at half voltage and double current.

J. B. Gibbs and A. M. Wiggins in discussing Mr. Wilson's paper stated that smaller transformers with hypernik cores and without special compensation will give about the same performance as the silicon steel transformers with the compensation described in the paper.

In discussing the paper by C. T. Weller, W. B. Kouwenhoven described a voltage divider which he had made in which the resistance was furnished by a tube of "manganin solution." This solution he said has a constant resistance and a tube one meter long and 1.08 mm. in diameter has a resistance of 24,000,000 ohms. He also described wire-wound resistances which he had used. R. L. Benbroeck described the method used in calibrating the 132-kv. potentiometer for phase angle. G. Thomas brought out the large volume of apparatus necessary in employing the resistance train method of measurement at high voltage and suggested that the capacitance train which involves much smaller equipment might be used with good results. Mr. Weller replied that he had considered the latter method but had not adopted it because capacity measurements are not as accurate as resistance measurements and capacitors tend to amplify harmonic voltages.

Commenting on the paper by Messrs. Stoller and Power, F. A. Byles claimed that a vibrating contact regulator specially constructed when used with saturated-core transformers will give very close regulation, that is 5 per cent above and below normal voltage.

To Members Going Abroad

Members of the Institute who contemplate visiting foreign countries are reminded that since 1912 the Institute has had reciprocal arrangements with a number of foreign engineering societies for the exchange of visiting member privileges, which entitle members of the Institute while abroad to membership privileges in these societies for a period of three months and members of foreign societies visiting the United States to the privileges of Institute membership for a like period of time, upon presentation of proper credentials. A form of certificate which serves as credentials from the Institute to the foreign societies for the use of Institute members desiring to avail themselves of these exchange privileges may be obtained upon application to Institute headquarters, New York.

The societies with which these reciprocal arrangements have been established and are still in effect are: Institution of Electrical Engineers (Great Britain), Societe Francaise des Electriciens (France), Association Suisse des Electriciens (Switzerland), Associazione Elettrotecnica Italiana (Italy), Koninklijk Instituut van Ingenieurs (Holland), Verband Deutscher Elektrotechniker E. V. (Germany), Denki Gakkwai (Japan), Norsk Elektroteknisk Forening (Norway), Elektrotechnicky Svaz Ceskoslovensky (Czechoslovakia), and The Institution of Engineers, Australia (Australia).

The 1929 Year Book Ready

The 1929 issue of the Institute's Year Book is ready for distribution and may be obtained upon application at headquarters. The book contains both alphabetical and geographical cataloging of Institute members, revised to January 1, 1929,

together with copy of By-Laws, Constitution, list of officers, list of committees, and other information pertinent to Institute activities.

AMERICAN ENGINEERING COUNCIL

REPORT ON STREET SIGNS, SIGNALS, AND MARKINGS

The report of the Council's Committee on Street Traffic Signs, Signals, and Markings is now off the press and is causing widespread interest and favorable comment. Many requests for copies are being received by L. W. Wallace, Executive Secretary. It is the ambition of the committee to have its recommendations carefully considered and adopted as a part of all national municipalities and in order to accomplish this the suggestions are made (a) that in each locality where there is a local engineering section, the president be supplied with a copy of the report with a recommendation that he in turn, through a local committee of his own, disseminate the information contained in the report; in communities where there is no local society, the local section of the national society would exercise this same method of information; in municipalities where there is neither local society nor local section, that there be an endeavor to organize a local section through some local engineer or civic organization. The Council offers to supply such local committee with a necessary number of reports and such other guidance as is required. It would appear that now, when traffic matters are so ultra important every community would benefit greatly by organizing to avail itself of this offer of the Council.

BOOK REVIEWS

Distribution of Electricity by Overhead Lines. By William T. Taylor. London, Charles Griffin & Co., Ltd. 265 pages., 6 by 9 in., cloth, illustrated, 1928. Price $6.50.

The book is intended for engineers engaged in planning, constructing and operating overhead distribution lines, and the practises presented are of general application and are not confined specially to English usage. Many references to American Standards are given. It is divided into seven chapters, the first two of which cover the history, study of the location, and general principles of design of a-c. distribution lines. The author considers the three-phase four-wire system the ultimate method of distribution. A very complete chapter on the calculations for the design of lines is given, followed by a chapter on the various mechanical details of design. The book concludes with a chapter on distribution maintenance.

Storage Batteries. By Morton Arendt. New York, D. Van Nostrand Company, Inc., 285 pages, 6 by 9 in., cloth, illustrated, 1928. Price $4.50.

The author's lectures to engineering students at Columbia College and to officers at the U. S. Submarine School over a number of years is the material from which the book has been developed. It is essentially a book for the practical man who is interested in the application, maintenance and operation of storage batteries. The complicated chemistry of the storage battery has only been included sufficiently to explain the characteristics and reactions of the cells. A brief introduction and history of the storage battery is followed by a chapter on general theory which is very simply explained. The method of manufacture and forming lead plates and the sulphuric acid electrolyte are described, and the factors influencing capacity and efficiency are discussed. A chapter on the details of construction of the lead cell is followed by a very practical chapter on installation, operation, and maintenance. Other subjects treated are the Edison nickel-iron cell, storage battery testing and numerous industrial applications.

Finding and Stopping Waste in Modern Boiler Rooms, edited by George H. Gibson. Philadelphia, Pa., Cochrane Corporation. 804 pages, 5 by 7 in., flexible cloth, illustrated 1928. Price $3.00.

This is the third edition of this steam plant manual, which has been brought up to date and includes new matter which makes it nearly double the size of the earlier editions. It comprises a reference book on steam plant which has been compiled from papers read before engineering societies, books, technical periodicals, etc., arranged in convenient form for managers and operators interested in boiler room efficiency. Five sections cover the subjects of fuels, combustion, heat absorption, boiler efficiency, and testing. The final section discusses heat balancing, water conditioning and protection from scaling and corrosion.

Mechanics for Engineers, by Julian C. Smallwood and Frank W. Kouwenhoven. New York, D. Van Nostrand Co., Inc., 185 pages, 6 by 9 in., cloth, illustrated, 1928. Price $2.50.

This book has been specially arranged for the use of engineering students by including a limited treatment of statics and kinematics and omitting such subjects as do not apply directly to an engineering course. As the average student cannot assimilate a comprehensive course in mechanics in the limited time usually allotted to it the engineering curricula, only the most essential subjects have been included. Emphasis is placed on the physical interpretation of the equations and laws presented. Interspersed throughout the book are problems on the various subjects, the first one being in each case worked out, followed by others for the student to solve. Answers to all the problems are given. For courses involving a time too limited to cover the entire text, certain articles designated by italic numbers are recommended for omission.

Radio, by Elmer E. Burns. New York, D. Van Nostrand Co., Inc. 255 pages, 5½ by 8 in., cloth, illustrated, 1928. Price $2.00.

This is essentially a book of first principles and is adopted to the requirements of students and experimenters in radio. The work is arranged to give first the fundamental electrical theory of radio and then a study of the different parts and their application to radio circuits. The mathematics employed are very simple and the book is written so as to be easily understood by the non-technical reader. The book starts with an explanation of simple receiving circuits, followed by chapters on electric batteries, magnetic action of electric currents, and electric circuits and Ohms law. This is followed by alternating-current phenomena and laws, and descriptions of the component parts and their functions in receiving circuits. The last chapter is on radio measurements. The book is prefaced by a "suggested course of study" which will be helpful to the student.

Laws of Management Applied to Manufacturing, by L. P. Alford. New York, The Ronald Press Co. 266 pages. 5½ x 8½ in., cloth, illustrated, 1928. Price $4.00.

The basis of this book is a paper by the author presented in 1926 to the American Society of Mechanical Engineers. The author has formulated about 50 laws which have been developed during many years of experience in manufacturing processes. Each of these fundamental laws or fundamental principles in manufacturing organizations is discussed fully and examples are cited showing the applicability of the law to specific instances of manufacturing, and the gains and improvements secured thereby. The book opens with a chapter on progress in manufacturing which calls attention to the developments of mass production, merging of large corporate units, discovery and application of new products, and the very common use of articles which a short while ago were considered luxuries. Progress in management is shown to have occurred as the result of the application of fundamental laws, which are discussed in the remaining chapters. The book is written in popular style and should be of interest to all factory executives.

Practical Television, by E. T. Larner. New York, D. Van Nostrand Co., Inc. 5½ by 8½ in., cloth, illustrated, 1928. Price $3.75.

This work presents a very interesting story of the general principles on which television is founded and treats the subject

in a manner which can be readily understood by the non-technical reader. The book distinguishes clearly between television, or the instantaneous transmission of images, and telephotography, or the transmission of photographs by wire or radio—two related subjects which are frequently confused. A brief summary of the early attempts in television and the historical aspects of the subject is given, and the selenium cell, which is the basis of all the early experiments in this field, is described. The photoelectric cell is the next development treated and one chapter is devoted to Continental and American researches in television. The subjects of optics, television technique, and recent developments conclude the book. The subject is probably one of the most fruitful in prospects for the research worker.

GRAPHICAL ANALYSIS OF ALTERNATING-CURRENT CIRCUITS, by Frederick W. Lee. Baltimore, Md. F. W. Medaugh, Civil Engineering Dept., The Johns Hopkins University. 76 pages, 6 x 9¼ in., cloth, illustrated.

It is of great advantage to the Student and Engineer to be able to visualize equations by means of graphs and this book develops a graphical method of solving alternating-current problems which is based on the analytical method as a foundation. It is divided into seven chapters, the first two of which are devoted to the principles of vector analysis and loci diagrams. The remaining chapters show graphical solutions of the fundamental equations of alternating current circuits. The book will be found very useful to the student by enabling him to visualize the full possibilities of a circuit without recourse to tedious solutions of long equations.

PERSONAL MENTION

EDWARD T. NEWTON has resigned his position as Assistant Electrical Engineer of the American Brass Company at Waterbury, Connecticut, to accept an appointment as Junior Examiner in the United States Patent Office at Washington, D. C.

W. L. BIRD has just been appointed Vice-President of the Kaminitiquia Power Company of Canada. Mr. Bird is a Fellow of the Institute, Past-President of the Canada Electrical Association, and a member of the Hydraulic Committee of the National Electric Light Association.

K. W. JOHANSSON, Switchboard Engineering Department, Westinghouse Electric International Company, sailed yesterday on the North German-Lloyd liner *Meunchen* for Cherbourg, whence he will proceed to Barcelona to supervise the installation of the electrical equipment which is one of the features of the International Exposition at Barcelona this summer.

HAMILTON MCRARY JONES, manager of the Department of the Americas of the Westinghouse Electric International Company, has recently resigned from that organization to accept a position as General Manager of the International Power Company and Vice-President of the Montreal Engineering Company in Montreal, Canada.

H. HOBART PORTER, President of the American Water Works and Electric Company, and of the Brooklyn City Railroad Company, has been elected to succeed L. B. Stillwell as Chairman of Engineering Foundation. Mr. Porter is also chairman of the Board of the West Penn Electric Company and Vice-President of the Queensboro Gas and Electric Company. He is also a member of the Division of Engineering of the Executive Board of the National Research Council and a Trustee of Columbia University.

R. J. S. PIGOTT who for three years was Mechanical Engineer with Stevens & Wood, Incorporated and later Consulting Engineer with Public Service Corporation of New Jersey Production Company and Smoot Engineering Corporation has returned to the Stevens & Wood organization as Consulting Mechanical Engineer. For several years Mr. Pigott was Chairman of the A. S. M. E. Main Research Committee and has had wide experience with industrial and power plants. In his new assignment he will devote his time mainly to solving the problems of industrial companies both in matters of power and production.

Obituary

Charles Schenck Bradley, whose biographical sketch was published in the May and July 1928 issues of the Institute JOURNAL, under the heading of "Some Leaders of the A. I. E. E., died Sunday, March 3, at St. Luke's Hospital, New York, N. Y. He was recently made an Institute Member for Life.

Cecil F. Wilson, Engineer of the New York Telephone Company and an Associate of the Institute since 1918, died in St. Luke's Hospital of pneumonia, January 22, 1929.

Born February 11, 1889 at Roseville, Ohio, Mr. Wilson was graduated from the Ohio State University in 1911 with a degree of M. E. in Electrical Engineering, and was elected a member of the Sigma Xi Society. During the summer of 1910 he was made switchboard operator of the Pittsburgh Plate Glass Company, Crystal City, Missouri, where he also had experience in general power electrical repair work. After graduation he joined the New York Telephone Company's office at Newark, New Jersey, as Telephone Engineer of the New Jersey Division, and in 1917 he was appointed Division Equipment Engineer. After a year's service there he was transferred to the New York Office as Engineer in the Engineering Department at 195 Broadway and remained there the rest of his period of service with the Company.

Harold P. Thomas, Foreman of the Test Department of the Lincoln Electric Company of Cleveland, Ohio, died February 7, 1929 at his home, East Cleveland, Ohio.

Mr. Thomas was born at Pittston, Pa., December 18, 1885. After passing through the grade schools, high school and preparatory school of his home town, he spent three years in the Medical School at the University of Pennsylvania. From 1902 to 1906, he was successively electrician's helper, colliery electrician and division electrician for the Lehigh Valley Coal Company, at Wilkes-Barre and for the next three years during the summer months continued this work with it. From 1910 to 1914 he was engaged in electrical repair work, following this with an appointment as Foreman of Winding, Assembling and Testing departmental work for the Dyneto Electric Company of Syracuse, New York. In 1917 he became Maintenance Electrician for the Willard Storage Battery Company, of Cleveland, Ohio; in 1918, neer for the American Ever Ready Company, Cleveland, Ohio and in 1921, the year in which he became an Associate of the Institute, he was appointed to the position of Test Inspector for for the Lincoln Electric Company.

Tester and final inspector of all motors manufactured by the Van Dorn Electric Tool Company, Cleveland, Ohio; in 1920, Foreman of the Assembly of Electric Fans and Small Motors for Adams Bagnall Electric Company; in 1920, Powerhouse Engi-

FERDINAND FOCH, Marechal de France—at 138 rue de Grenelle, Paris, March Twentieth, Nineteen Hundred and Twenty-Nine.

Elected an Honorary Member of the Institute and other Founder Societies 1921.

It will be remembered by Institute members that Marshall Foch visited the Engineering Societies Building, New York, March 13, 1921, the date under which a medallion of commemoration was mounted on the West wall of the Main Foyer, just to the right of the case containing the regimental colors of the Twenty-Fourth Engineers, Service of Supplies, A. E. F., and the Twenty-Seventh Engineers, American Engineering Troops, Advance Section, A. E. F., who served under the Marshall at Marne-Aisne, Aisne-Vesle, St. Mihiel, and the Argonne-Meuse.

He died as he lived—a great man.

A. I. E. E. Section Activities

GROUP ACTIVITIES PROPOSED IN NEW YORK SECTION

A movement is now under way within the New York Section to divide the section membership into groups according to the field in which they are interested. At the present time four such groups are in view, namely; the Power group, the Communication, Transportation and Illumination groups. It is proposed that these individual groups will each hold a number of meetings during each administrative year for the presentation and discussion of papers of particular interest to them. The groups will be so arranged and divided into committees as to be able to handle completely their own meetings and affairs in general. This will provide an opportunity for a large number of Section members to take part in Section affairs, and permit also for wider discussion participated in by men who ordinarily do not get such opportunity at the large general monthly meetings. The monthly meetings on subjects of general interest to the entire Section membership will be continued. The Power group has set the date for its first meeting for April 10th and a program is being prepared. This group is under the chairmanship of George Sutherland of the New York and Queens Electric Light and Power Company. The chairman of the other three groups are as follows: H. S. Sheppard, Communication; T. R. Langan, Transportation; E. E. Dorting, Illumination.

FUTURE SECTION MEETINGS

Cleveland

Communication. Electric League Rooms, Hotel Statler. April 18.

Annual Dinner Meeting. Speaker: R. F. Schuchardt, President, A. I. E. E. Electric League Rooms, Hotel Statler. May 23.

Columbus

Joint meeting with Ohio State University Branch. Smoker and buffet luncheon. April 26.

Power Supply for Railway Signals and Automatic Train Control, by C. F. King, Jr., Westinghouse Electric & Mfg. Co. Afternoon session, 2:30 p. m., Ohio Power Co. Building, Newark, Ohio. Inspection of Pennsylvania Railroad automatic train control substation in Newark. Evening session, 6:30 p. m., Chittenden Hotel, Columbus. Ladies Night. Election of officers. May 24.

Detroit-Ann Arbor

Relays, by H. W. Collins, Detroit Edison Co., and J. R. North, Commonwealth Power Corp. Detroit, April 16.

Lehigh Valley

National Electric Code, by A. R. Small, and

Electrical Features of Mack Plant, by W. P. Mitchell. Americus Hotel, Allentown. April 19.

Power Transmission, by A. O. Austin. Inspection of Hazleton Service Depot. Altamont Hotel, Hazleton. May 10-11.

Madison

Some Recent Research Developments of the Westinghouse Electric & Mfg. Co., by C. E. Skinner, Asst. Director of Engg. April 16.

Election of Officers and showing of Baron Shiba's high speed film. May 22.

Pittsburgh

Ladies Night. Meeting and Dinner Dance. May 14.

Pittsfield

Demonstration of artificial lighting and high-voltage phenomena. Pittsfield Works, General Electric Co. Joint with Engg. Society of Western Mass. April 16.

St. Louis

April 17.
May 15.

Saskatchewan

Annual Meeting. Election of Officers. April 26.

Seattle

Joint meeting with University of Washington Branch. Program under direction of Prof. George L. Hoard, University of Washington. April 16.

Competitive Papers. May 21.

Sharon

Youngstown, Ohio. May 4.

Toronto

Vacuum Tube Devices, by J. V. Beisky, Westinghouse Electric & Mfg. Co. Hamilton Canadian Westinghouse Company Auditorium. April 21.

Ladies Night. Election of Officers. May 10.

Utah

Recent Developments in the Telephone Field, by H. W. Oddie, Transmission and Protection Engr., M. S. T. & T. Co. April 15.

Joint meeting with University of Utah Branch. May 13.

Vancouver

Concentrators at Trail, by H. A. Moore, Toronto. May 7.

Washington

High-Capacity Mercury Arc Rectifiers, by F. A. Faron, General Electric Co. May 14.

PAST SECTION MEETINGS

Boston

Transatlantic Telephony, by Dr. J. O. Perrine, American Tel. & Tel. Co. Buffet supper. February 12. Attendance 150.

The Passamaquoddy Tidal Project, by M. B. Pike, Dexter P. Cooper, Inc. March 5. Attendance 125.

Chicago

The Electrical Industry in America, by Paul S. Clapp, Managing Director, N. E. L. A. Joint meeting with Electrical Section, Western Society of Engineers. Dinner to the speaker and Executive Committee. January 21, Attendance 300.

Boulder Dam Project. R. F. Schuchardt, President, A. I. E. E., introduced the speaker, Prof. Daniel W. Mead, Consulting Engineer and one of the three engineers appointed by President Coolidge to report on the economic and engineering phases of this project. Slides. Joint meeting with Electrical Section, Western Society of Engineers, preceded by a dinner in honor of the speaker. March 11. Attendance 560.

Cincinnati

High-Voltage, High-Frequency Phenomena, by F. W. Peek, Jr., Mgr., Transformer Engg. Dept., General Electric Co., Pittsfield, Mass. Joint meeting with Engineers' Club of Dayton, Ohio. February 12. Attendance 280.

Cleveland

The Development of Power Machinery, by F. D. Newbury, Mgr., Power Engg. Dept., Westinghouse Electric & Mfg. Co. Slides. A dinner to the speaker preceded the meeting. February 21. Attendance 60.

Columbus

The Influence of Recent Lightning Investigations on Transmission Line Development, by C. L. Fortescue, Consulting Transmission Engr., Westinghouse Electric & Mfg. Co. Illustrated. A short article on the new Deion Circuit Breaker was read by Prof. W. L. Everitt, Dept. of Electrical Engineering, Ohio State University. February 8. Attendance 45.

Connecticut

New England Power Systems Interconnections, by C. W. Mayott, Mgr., Connecticut Valley Power Exchange. The meeting, held at Norwich, was preceded by three reels of moving pictures—"Current in the Telephone Circuits," "Selection and Gathering of Long Leaf Pine Poles," and "Apparatus for Transmission of Pictures." January 15. Attendance 63.

Electrical Development in the Province of Ontario, by P. A. Borden, Development Engr., The Bristol Company, and

Electrolytic Condensers, by F. W. Godsey, Jr., Yale University. Meeting held at Waterbury, February 26. Attendance 36.

Dallas

Televox, by J. L. McCoy, Westinghouse Electric & Mfg. Co. February 4. Attendance 101.

Electric Welding of Steel Buildings and Bridges, by F. P. McKibben, Consulting Engr., General Electric Co. Slides. Brief reports concerning program of Regional Meeting to be held in Dallas. Local Sections of four other national societies invited. February 20. Attendance 179.

Denver

Recent Laboratory Developments in the Communication Art, by R. B. Bonney, Educational Director, The Mountain States Telephone and Telegraph Co. Slides and educational sound pictures demonstrating carrier telephony. Reports of the Membership and Program Committees. Dinner. February 15. Attendance 60.

Detroit-Ann Arbor

Light Sources in General, by Frank Benford, Research Laboratory, General Electric Co. Business session. President R. F. Schuchardt's message in the January 1929 issue of the JOURNAL was read and discussed. Joint meeting with Michigan Section, Illuminating Engineering Society, preceded by a dinner. February 19. Attendance 100.

Erie

Aviation As a Commercial Proposition, by G. G. Jury, Cleveland Traffic Representative of Stout Air Service. February 19. Attendance 100.

Fort Wayne

Railroad Electrification, by J. V. B. Duer, Elec. Engr., Pennsylvania Railroad. Motion pictures were shown before and refreshments served after the meeting. February 28. Attendance 55.

Houston

Televox, by J. L. McCoy, Westinghouse Electric & Mfg. Co. Demonstration. February 7. Attendance 180.

Electric Welding of Steel Bridges and Buildings, by F. P. McKibben, Consulting Engr., General Electric Co. Illustrated. Joint meeting with Houston Engineers Club and Sections of seven national societies. Meeting preceded by a dinner. February 21. Attendance 160.

Indianapolis-Lafayette

Aircraft Development, by Major J. E. Fickel, Wright Field, Dayton, Ohio., and

Present Status of Electric Welding of Structural Work, by A. M. Candy, Welding Engr., Westinghouse Electric & Mfg. Co. Motion pictures of aircraft development. Joint meeting with Indiana Engineering Society. February 7. Attendance 55.

A New Hot Cathode Ray Oscillograph and Its Application to Lightning and Switching Surges, by R. H. George, Research Associate, Engineering Experiment Station, Purdue University. Demonstration. March 1. Attendance 105.

Ithaca

Frequency Measurement and Control, by Dr. Leo Behr, Leeds & Northrup Co. Demonstration of recording frequency meter. February 15. Attendance 150.

Kansas City

Some Problems of the Gas Industry, by Maj. T. J. Strickler, Vice-President and General Mgr., Kansas City Gas Co., and

Radio Transmission, by R. G. McCurdy, Mgr., Radio Dept., Graybar Electric Co., Kansas City. Coffee and sandwiches served. February 26. Attendance 70.

Lehigh Valley

Welding—Welds—Welders, by Chas. Schenck, Prof. C. D. Jensen and H. J. Bowles. Slides. Dinner was served, during which Prof. Morland King, Lafayette College, spoke on the Winter Convention. Prof. S. S. Seyfert, Lehigh University, gave a description of the Packard Electrical and Mechanical Building. Joint meeting with Engineers Club of the Lehigh Valley and Lehigh University Student Branch at Lehigh University. February 23. Attendance 163.

Los Angeles

Telephone Communication over Deep Sea Submarine Cables, by H. W. Hitchcock, Chief Engineer, Southern California Telephone Co. Preceded by a dinner. February 5. Attendance 90.

Inspection trip to the Mutual Office, Southern California Telephone Co. February 9. Attendance 47.

Annual joint meeting with Student Branches of California Institute of Technology and the University of Southern California. (See complete report in Student Activities department. March 5. Attendance 240.

Louisville

Network Broadcasting, prepared by G. A. Duncan, Long Lines Dept., A. T. & T. Co., and presented by M. W. Keyser, District Transportation Engr. Dean B. M. Brigman, University of Louisville, described the A. I. E. E. National and Regional Prizes. J. Emmett Graft, Chief Operator, Station WHAS, and Milo Utterback, Assistant Operator, described in detail the operation of the station. January 31. Attendance 40.

Inspection trip to Corhart Refractories Company Plant. S. W. Schroeder, Chief Chemist, conducted a tour of the Plant. After the inspection trip the meeting adjourned to the office where Mr. Schroeder answered questions regarding material produced and its applications. Guests of A. S. M. E. February 21. Attendance 21.

Lynn

Present Day Aeronautics, by Lieut. A. F. Hegenberger. Lantern slides and moving pictures. February 20. Attendance 325.

Inspection trip to Everett Water Gas Plant of Boston Consolidated Gas Co. D. C. Reynolds, Chief Engr., conducted party through the plant. March 2. Attendance 30.

Manufacture of City Gas, by Edwin R. Clarke, Asst. Supt., Lynn Gas & Electric Co.;

Gas, the Better Fuel, by W. A. Oates, Heating Engr., Lynn Gas Gas & Elec. Co.;

Radio Frequency Standardization, by R. S. Davidson, Thomson Research Laboratory, General Electric Co., and

Quiet Induction Motors, by L. E. Hildebrand, Motor Engg. Dept., General Electric Co. Local convention night. March 6. Attendance 70

Madison

The Photoelectric Cell and Its Uses in Communication, by Dr. J. O. Perrine, American Tel. & Tel. Co. Demonstrations. Meeting preceded by a dinner in honor of the Bell System representatives. February 19. Attendance 360.

Minnesota

Banquet meeting of the Third Annual Engineering Conference of the North Central Electric Association. Members of Minnesota Section, A. I. E. E. invited. Talk by L. W. W. Morrow, Editor, *Electrical World*. January 21. Attendance 203.

Nebraska

Delayed Speech and Other Recent Discoveries and Inventions of the Bell Telephone Laboratories, by S. P. Grace, Assistant Vice-President, Bell Telephone Laboratories, Inc. Demonstrations. February 19. Attendance 1800.

Oklahoma

Commercial Applications of Carrier Currents to Transmission Lines, by C. E. Bathe, Oklahoma Gas and Electric Co. B. D. Hull, Vice-President, gave an outline of the many features of the Regional Meeting to be held in Dallas May 7-9, and urged that as many as possible attend. Chairman instructed to appoint a committee of judges to determine the best and second best student papers presented for prizes at the 1929 joint meeting of the Section and the two Student Branches in Oklahoma. February 27. Attendance 23.

Philadelphia

Railroad Electrification in the Philadelphia Area, by J. V. B. Duer, Elec. Engr., Pennsylvania Railroad, and N. E. Funk, Ass't. General Mgr., Philadelphia Electric Co. Dinner preceded the meeting. February 11. Attendance 275.

Pittsburgh

The Extinction of an Alternating-Current Arc, by Dr. Joseph Slepian, Consulting Research Engr., Westinghouse Electric & Mfg. Co. The paper was followed by a demonstration of the Deion Circuit Breaker at the High Power Laboratory. Guests of Westinghouse Electric & Mfg. Co. at dinner. Joint meeting with Electrical Section, Engineers Society of Western Pennsylvania. February 12. Attendance 570.

Pittsfield

My Life with the Foreign Legion, by Bennett J. Doty. The speaker was entertained at dinner prior to the meeting. February 5. Attendance 800.

Conowingo and 220-Kv. Interconnection Developments, by R. A. Hentz, Engr., Philadelphia Electric Co. February 19. Attendance 80.

What's Coming in Aviation, by W. B. Stout, President, Stout Metal Airplane Co. (Division Ford Motor Co.). March 5. Attendance 500.

Portland

Economics of Interconnection of Power Systems, by O. L. LeFever, General Supt., Northwestern Electric Co. Film of the Great Northern Tunnel Construction. Refreshments. February 26. Attendance 70.

Providence

The Narragansett Electric Company's System, by J. W. Young, Elec. Engr., Narragansett Electric Co. Refreshments. March 5. Attendance 130.

St. Louis

Annual Dance. Attendance prizes awarded to Gordon W. Gerell, C. J. Embree and Raymond C. Hase. February 20. Attendance 108.

San Francisco

Electric Welding of Steel Bridges and Buildings, by F. P. McKibben, Consulting Engr., Black Gap, Pa., and Schenectady, N. Y. Joint meeting with Sections of A. S. C. E., A. S. M. E., American Welding Society and American Institute of Architects. Dinner in honor of Mr. McKibben. January 25. Attendance 482.

Seattle

Welding of Steel Buildings, Bridges and Other Structures, by F. P, McKibben, Consulting Engr., Black Gap, Pa., and Schenectady, N. Y. A resolution was passed placing the Section on record as opposed to the proposed Engineers License Law for the State of Washington. All local engineering organizations invited. A comedy feature "A Night on Test" was presented by Ex-G. E. Test Men. February 12. Attendance 220.

Sharon

The Deion Circuit Breaker, by B. P. Baker, Westinghouse Electric & Mfg. Co. Moving pictures of China. February 5. Attendance 136.

The Role of Physics in Industry, by Dr. L. O. Grondahl, Director of Research, Union Switch & Signal Co. Moving picture—"Driving the Longest Railroad Tunnel in the Western Hemisphere." March 5. Attendance 80.

Spokane

Power Factor from a Central Station Viewpoint, by W. S. Hill, General Supt., Gray's Harbor Railway & Light Co. Mr. Baughn, Chairman of the Meetings and Papers Committee, reported that the April meeting will be held in Moscow as a joint meeting of the Section and Student Branches of the University of Idaho and Washington State College. February 21. Attendance 16.

Springfield

Making Sound Visible and Light Audible, by J. B. Taylor, Consulting Engr., General Elec. Co. Slides and demonstrations. January 14. Attendance 117.

The Experiences of an Electrical Engineer in Central and South America, by S. Q. Hayes, General Engr., Westinghouse Electric & Mfg. Co. Delineascope pictures. February 18. Attendance 70.

Syracuse

Airport Lighting, by A. H. Clarke, Illumination Engr., Crouse Hinds Co. Miniature air port was displayed. February 25. Attendance 135.

Toledo

Televox, by J. L. McCoy, Westinghouse Electric & Mfg. Co. Demonstrations. Chairman Featherstone read a description of Baron Shiba's camera, illustrating it with lantern slides. The following motion pictures shown: "Driving the Longest Railroad Tunnel in the Western Hemisphere;" Baron Shiba's film on airplane research. Meeting preceded by a dinner at which Vice-President J. L. Beaver gave a short talk. Joint with A. S. M. E. Ladies invited. March 7. Attendance 500.

Toronto

Deion Circuit Breaker, by H. M. Wilcox, Westinghouse Electric & Mfg. Co. Slides. February 8. Attendance 95.

Gatineau-Toronto Power Line, by A. E. Davison, Engg. Dept., Hydro-Elec. Power Commission. February 22. Attendance 105.

Urbana

Arcing Phenomena at the Contact of a Switch, by R. E. Tarpley, Research Graduate Assistant, Dept. of Elec. Engg., University of Illinois. Slides. February 13. Attendance 25.

The Photo electric Cell and Its Uses in Communication, by Dr. J. O. Perrine, American Tel. & Tel. Co. February 21. Attendance 365.

Utah

The Photo electric Cell and Its Applications, by Dr. H. T. Plumb, Engr., General Electric Co., Salt Lake City. Demonstrations. February 18. Attendance 100.

Vancouver

Annual student meeting. (See complete report in Student Activities dept.). March 5. Attendance 35.

Washington

Automatic Train Control, by W. H. Reichard, Consulting Elec. Engr., General Railway Signal Co. Slides. Refreshments served. Dinner in honor of the speaker. February 12. Attendance 173.

A. I. E. E. Student Activities

STUDENT BRANCH CONVENTION AND NEW YORK SECTION MEETING

On April 26th the New York Section of the Institute will hold its annual Student Branch Convention and regular monthly Section meeting. The students from the eight colleges in the New York District will present papers in competition for the $25.00 prize offered yearly by the Section. The presentation of the student papers will take place during an afternoon session held in the Engineering Building, 33 West 39th Street, New York. A committee of judges appointed by the Executive Committee will make the award. The morning of the 26th will be devoted to inspection trips arranged by and for the students. Immediately following the afternoon session there will be a student dinner at which it is hoped to have as a speaker some very prominent engineer. At previous conventions some 500 students have participated.

In the evening the New York Section will hold its regular meeting at which Hugh Cooper, well known consulting engineer will deliver an interesting talk on hydroelectric developments abroad. Complete details relative to the student meeting and as to the evening session will be available later. The regular meeting will take place in the Engineering Auditorium at 8.15 p. m.

STUDENT CONVENTION HELD IN PHILADELPHIA

The Fifth Annual Student Convention of the Eastern part of District No. 2 was held at the Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, on March 11, 1929. Beginning at 11:00 a. m., the following program was presented:

Address of Welcome, Dr. Harold Pender, Dean, Moore School of Electrical Engineering.

The Klydonograph, H. G. Wiest, '29, Lehigh University.

Mercury Arc Rectifiers, D. B. Spangler, '29, Chairman, Swarthmore College Branch.

Cathode Ray Oscillograph, Otto Meier, Jr., '29, University of Pennsylvania.

Some Developments in Power Plant Frequency Control, D. D. Lewis, '29, Haverford College.

At a luncheon meeting held in the Christian Association building, a talk was given by Mr. Sidney K. Wolf, Acoustic Engineer, Electrical Research Products, Inc., on the subject *Movietone Recording and Reproducing Equipment.*

The entire party then attended the afternoon show at the Fox-Locust Theatre and, after the close of the program, inspected the movietone apparatus, under the direction of Mr. S. K. Wolf and the operators.

After the return to the Moore School building, a talk on *Psychology of Switchboard Arrangement* was given by William W. Braunwarth, '29, University of Pennsylvania, and this was followed by an inspection of the electrical engineering laboratories.

The dinner and evening program were held in the Christian Association building, and the following two addresses were given:

Student Branch Activities, H. H. Henline, Assistant National Secretary.

Address, Dr. George W. McClelland, Vice-Provost, University of Pennsylvania.

The orchestra of the Engineers Club of Philadelphia furnished music during the evening and, after the above addresses, skits were given by students of University of Pennsylvania, Lehigh University, and Drexel Institute. At the opening of the morning session, the following judges were appointed to award the prizes for the technical papers: D. M. Way, Chairman, Drexel Institute Branch; W. V. G. Eakins, Chairman, Princeton University Branch, and Mr. Clay of Lafayette College. During the evening program the decisions of the judges were announced, and T. E. Manning, Chairman, University of Pennsylvania Branch, presented prizes as follows: $10.00 each to H. G. Wiest and Otto Meier; $5.00 each to D. B. Spangler and D. D. Lewis.

The Convention was sponsored by the Philadelphia and Lehigh Valley Sections, and the following schools participated: Delaware, Drexel, Haverford, Lafayette, Lehigh, Pennsylvania, Princeton, and Swarthmore.

The attendance at the various events varied from about 165 to 190.

VANCOUVER SECTION HOLDS ANNUAL STUDENT MEETING

The annual student meeting of the Vancouver Section was held at the University of British Columbia on the evening of March 5, 1929. After a talk by C. W. Colvin, Chairman of the Section, on the advantages of Student enrolment in the Institute, the following program was presented by seniors:

Some Applications of Thermionic Vacuum Tubes, Mr. Blackett.

Diesel Engines, Mr. Jagger.

Power Rectifiers, Mr. Morrison.

Modern Heavier-Than-Air Craft, Mr. Bishop.

Electrical Measuring Instruments, Induction Type, Mr. Dhami.

The papers were well presented, and the 35 persons present were pleased with the program.

ANNUAL JOINT MEETING OF LOS ANGELES SECTION WITH STUDENT BRANCHES

Continuing their plan of holding an annual joint meeting with a program supplied by students, the Los Angeles Section and California Institute of Technology and University of Southern California Branches met at the California Institute of Technology on the evening of March 5, 1929. During the early part of the evening, music was furnished by members of the Branches. After a dinner, the following program was presented:

Output and Power Factor of a Constant-Current Transformer, D. R. Stanfield, University of Southern California.

Effect of Frequency upon the Operation of the Electro-Magnetic Oscillograph, D. M. Wright and John Gilroy, University of Southern California.

Hoover, an Engineer President, Robert Good, University of Southern California.

Control Features of the Wind Tunnel, William Lewis, California Institute of Technology.

Following the presentation of the papers, high-voltage demonstrations were given in the million-volt laboratory, and there was a tour of inspection through the Aeronautics Building where the wind tunnel equipment was demonstrated. The attendance was 240.

MONTANA STATE COLLEGE BRANCH HAS RHODES SCHOLAR

Matt Pakkala, senior in electrical engineering at Montana State College, has been awarded the Rhodes Scholarship to Oxford University, England. He was selected from a group of ten candidates from the colleges in the state of Montana, and will begin his work at Oxford next October to read for a degree in mathematics which he expects to receive after three years' study. Mr. Pakkala is the first student of Montana State College to receive the Rhodes Scholarship, and is considered to be the most brilliant mathematician who ever attended that school. The authorities at Oxford have granted him senior standing without examination.

STUDENT BRANCH ACTIVITIES

THOS. C. McFARLAND

Counselor University of California Branch, and Chairman Committee on Student Activities, Pacific District

It is generally recognized that the great problem in the conduct of A. I. E. E. Student Branches is to secure a larger participation in the Branch affairs by the student members. The real solution is, doubtless, to make the meetings of sufficient interest to all the members that they will voluntarily be active. But how can the interest of the individual student be increased? How can meetings be conducted so that the members will derive the maximum benefit?

There is an old saying to the effect that he who puts the most into the project gets the most in return. There may be exceptions but when the project happens to be an organization such as the American Institute of Electrical Engineers there is no denying the validity of that observation. In the Branches those taking the greatest interest are chiefly the ones having responsibilities. The officers and committee chairmen take the greatest interest and, consequently, derive the most good. If the membership is very small the work of the Branch can possibly be distributed so that all will feel they are contributing something. With the larger Branches, however, only a relatively small number can serve in this way. What shall we do to interest the majority?

In the University of California Branch the problem of maintaining interest is a very real one for the membership is quite large. In an attempt to solve this the following plan has been adopted. At the time of the initiation an expression of opinion is obtained from each of the members as to the topics that interest him most. This is done through the medium of a questionnaire in which four questions are asked. These questions are:

1. In which of the following activities are you most interested? (A tabulation of activities about as indicated by the list of Institute Technical Committees followed).
2. Upon which of the above topics (or some phase thereof) are you willing to prepare a paper for a Branch meeting?
3. What type of industry or what specific plants would you like to visit during the year?
4. On which of the following committees would you prefer serving? (A list of the Branch committees follows).

The answers to the fourth question make possible the appointment, by the Chairman, of committees that may be expected to function. From the first and second questions material is obtained that enables the Program Committee to know what type of meetings are most likely to be successful and also to definitely plan a program for the whole semester. The interests as

expressed in the answers to these questions can be grouped into a small number of general headings thus permitting the committee to schedule a program in which each group will be represented. It is recommended that not only should the speakers for the meetings be assigned but also that at least two men be designated to contribute oral discussion on each paper. Furthermore, the choice of outside speakers and of motion pictures or of slides is influenced by the answers given to these questions.

The results thus far indicate that the plan has considerable merit. The worth of the questionnaire has been fully demonstrated. There has been a large amount of material from which to choose, thus making it easier for the officers and committees to function. (Unless the members will sincerely cooperate and answer all the questions the plan is doomed to an early failure). Unfortunately, the plan has not been strictly adhered to in the conduct of meetings and there has not been the improvement that was hoped for. Too few of the members have been asked to give papers and to contribute discussion, with the result that the original intent of the plan has been largely defeated. It is hoped that in another semester this difficulty can be ironed out.

PAST BRANCH MEETINGS

Municipal University of Akron

Inspection trip to the automatic telephone exchange at Canton. March 6. Attendance 20.

Alabama Polytechnic Institute

What the Young Engineer May Expect on Entering a Public Utility, by H. E. Cox, Vice-President, Birmingham Electric Co. February 15. Attendance 47.

Mexico, by A. Nieto, student;

Tesla Coils, by D. O. Baird, student, and

The New Method of Running Automobiles, by B. S. Burton, student. February 21. Attendance 39.

Outdoor Meters, by W. L. Cochran, student, and

Experiences with the Railroad, by W. P. Smith, student. C. T. Ingersoll, president of Eta Kappa Nu Chapter, presented the Eta Kappa Nu slide rule to Paul Break for the best article for the "Auburn Engineer" during his sophomore year. February 28. Attendance 38.

Discussion of plans for Engineers Ball. Mr. Bynum, student, read the constitution of the newly formed Engineers Club and it was accepted as read. March 7. Attendance 34.

University of Arizona

Electrically Operated Refrigerators, by C. K. Gieringer, student. January 9. Attendance 8.

High-Voltage Phenomena in Thunderstorms, by Jack Hopper, Chairman, and

Synchronized Production of Sound and Scene, by Gene Magee, student. January 16. Attendance 10.

Motion pictures entitled respectively "Induction Regulator," "Automatic Substations," and "Power Transformers." January 23. Attendance 9.

Tracing the Development of A. I. E. E., by Prof. J. C. Clark. February 6. Attendance 13.

Thomas Edison, by Frank Henderson, student. The following officers elected: Vice-Chairman, C. K. Gieringer; Secretary, Wm. Tremaine; Treasurer, Frank Henderson. February 13. Attendance 19.

George Westinghouse, by Carl Gieringer, student;

Samuel Morse, by Rickardo Manzo, student, and

The Photoelectric Cell, by Leo Killian, student. February 20. Attendance 17.

History of Mathematics, by Fred Denny, student;

Electrical Precipitation of Gas Streams, by Roy Goar, student, and

Electric Welding, by Stanley McKinley, student. February 27. Attendance 15.

Talking Motion Pictures, by Kenneth Kelton, student. March 6. Attendance 18.

University of Arkansas

Application of X-Rays to Engineering, by W. M. Roberts, Asst. Prof. of Physics. February 15. Attendance 13.

Armour Institute of Technology

The Movietone and the Photoelectric Cell, by L. S. O'Roark, Employment Director, Bell Telephone Laboratories, Inc. Joint meeting with Lewis Institute Branch. February 14. Attendance 910.

Neon Signs, by Mr. Lindsey, Federal Electric Co. February 25. Attendance 157.

Brooklyn Polytechnic Institute

Derivation of Rates, by G. W. Trapani, student, and

Tesla Coils, by F. Seymers, N. Y. & Q. Electric Light & Power Co. January 10. Attendance 43.

Electrical Measuring Instruments, by Mr. Corby, Weston Electrical Instrument Corp. Refreshments. February 13. Attendance 51.

Bucknell University

Prof. W. K. Rhodes, Counselor, gave a short talk on the development of Electrical Engineering at Bucknell and the installation of the Branch. The purpose of the meeting was to make the Freshman Engineering students better acquainted with Branch activities and with the upper classmen. February 12. Attendance 19.

Application of Electricity to the Iron and Steel Industry, by F. O. Schnure, Alumnus, Electrical Superintendent, Sparrow's Point (Md.) plant, Bethlehem Steel Co. Slides. February 21. Attendance 40.

California Institute of Technology

Business Meeting. March 5. Attendance 23.

University of California

Boulder Dam, by A. P. Davis. Initiation Banquet. Dean C. L. Cory acted as toastmaster. Prof. T. C. McFarland welcomed the new members and explained the purposes and functioning of the organization. G. A. Anderson gave a brief talk on Engineering Unity. Prof. F. H. Cherry presented pins to the twenty-two new members. Musical entertainment. February 28. Attendance 70.

Carnegie Institute of Technology

Electrical Power, Plant to Consumer, by M. C. Zilberman, student, and

Current and Voltage Distribution in Transmitting Antennas, by R. S. Tener, student. Social meeting, with refreshments and smoker after program. February 20. Attendance 28.

Case School of Applied Science

Business Meeting. Election of the following officers for year 1929-1930: President, R. B. McIntosh; Vice-President, T. S. Hudson; Secretary, H. L. Brouse; Treasurer, V. S. Roddy; Safety Representative, K. G. Young. February 26. Attendance 37.

Clemson Agricultural College

Student Activities, by W. C. Snyder, student;

Engineering Achievements of 1928, by J. B. Bevill, student;

Current Events, by S. B. Harper, student, and

Water Power Development in South Carolina, by Prof. S. R. Rhodes, Counselor. February 21. Attendance 17.

Cooper Union

High-Frequency Phenomena, by C. H. Coles, 5th-year Night School student. Demonstrations. February 20. Attendance 80.

Film—"The Single Ridge." A representative of the Okonite Company was present to answer questions. March 6. Attendance 33.

Visit to Walker Street Building of A. T. & T. Co. March 10. Attendance 30.

University of Detroit

Operation of Automatic Sub-Stations, by J. E. Theriault, Instructor of Operators School, Detroit Edison Co. Movies: "The Single Ridge" and "Driving the Longest Railroad Tunnel in the Western Hemisphere." Luncheon preceded meeting. February 5. Attendance 70.

The Sonnic System, or Transmission of Power by Vibrations, by Dr. Leucutia, Harper Hospital;

Growth of the S. A. E. in Detroit, by B. L. Lemmon. Chairman of Detroit Section, and

Automotive and Specialized Engineering, by O. T. Kreusser, Director, General Motors Proving Grounds. Joint meeting with Engineering Society of the University. March 4. Attendance 245.

Duke University

Ship Electrification, by R. A. Cassidy, student, and

Power Involved in Voice Reception, by Prof. W. J. Seeley, Counselor. Moving picture, "Electrical Measuring Instruments" Business session. March 1. Attendance 22.

University of Florida

Building a Radio Station, based upon problems encountered in erecting the University station WRUF, by Dr. J. R. Benton, Dean of the Engineering College. March 11. Attendance 27.

Georgia School of Technology

Business Meeting. Prof. T. W. Fitzgerald, Head of the Electrical Engineering Dept., nominated for appointment as Counselor to succeed Prof. Hannaford, who resigned from the faculty. February 19. Attendance 27.

Outstanding Developments in the Electrical Industry in 1928, by John Liston, General Electric Co. Slides. February 27. Attendance 48.

State University of Iowa

Carrier Current Telephony, by Mr. Baumgartner, student, and

Street Railways, by Mr. Finch, student. November 28. Attendance 36.

Oil-Electric Locomotives, by Mr. Hemphill, student, and

Boulder Dam, by Mr. Hatch, student. December 5. Attendance 33.

High-Voltage D-C. Generators, by Mr. Hicklin, student, and

Sound Moving Pictures, by Mr. Holmes, student. January 16. Attendance 29.

Business Meeting. January 30. Attendance 28.

Reconstruction of Two 17,000 Kv-Ampere Generators, by Mr. Johnston, student, and

Phillipine Islands, by Mr. Mariano, student. February 13. Attendance 31.

Flashing of Synchronous Converters, by Mr. Mathis, student, and

Niagara Power Plant, by Mr. Martinez, student. February 27. Attendance 32.

University of Kansas

What Makes a Successful Engineer, by R. O. Shepp, student, and

Photoelectric Cells, by Norvel Douglas, student. Business session. February 21. Attendance 27.

University of Kentucky

Prof. W. E. Freeman, Counselor, explained the motion picture films: "Gas-Electric Buses" and "Largest Single-Unit Electric Locomotive." February 19. Attendance 40.

Lehigh University

Welding, by Charles Schneck, Production Engineer, Bethlehem Steel Co.;

Welding Research Work at Lehigh, by Prof. C. D. Jensen, and

Training and Testing Welders, by H. J. Bowles, Welding Supervisor of Saucon Division, Bethlehem Steel Co. Joint meeting with Lehigh Valley Section and Engineers Club of Lehigh Valley, preceded by a dinner. Number of after-dinner speeches by prominent engineers and professors. February 23. Attendance 175.

Lewis Institute

Joint meeting with Armour Institute of Technology Branch. (See report under Armour Institute). February 14. Attendance 63.

University of Louisville

Neon Signs, by G. M. Miller, Supt. of Distribution, Louisville Gas and Electric Co. Two-reel film "The Edison Storage Battery" shown by N. C. Pearcy, Louisville Gas & Elec. Co., Secy., Louisville Section, A. I. E. E. Chairman Evans urged that a number of Branch members submit papers. Refreshments were served. February 15. Attendance 20.

University of Maine

A Summer with General Electric Co., by E. F. Cooper, '29. Films—"Power Transformers" and "Beyond the Microscope." March 7. Attendance 15.

Marquette University

The Transmission of Radio Currents on Telephone Cables, by John Gibbons, Wisconsin Telephone Co. Slides and instruments. Business session. November 1. Attendance 33.

Hardships Endured in the Building of the First Transcontinental Railroad, by T. C. Hatten, Chief Engr., Metropolitan Sewage Commission. A mock trial was held in which A. Jackson, J. Higgins, W. Clancy, G. Morrison and R. Eiff took part. December 13. Attendance 65.

Correction of Radio Interference Caused by Electric Company Equipment, by T. Bailey. Business session. January 17. Attendance 22.

Michigan State College

Business Meeting. November 12.

Business Meeting. January 24.

University of Michigan

Talking Movies, by Dr. J. O. Perrine, American Tel. & Tel. Co. Illustrated. Two reels of talking movies shown. February 27. Attendance 450.

University of Minnesota

Legal Problems Arising in Engineering, by A. W. Groth, Minneapolis Attorney. February 14. Attendance 150.

University of Missouri

Scientific Curiosity, by A. K. Bushman, General Electric Co. Films—"Beyond the Microscope" and "Thomas A. Edison." February 19. Attendance 41.

Montana State College

Counting Atoms and Electrons, by Dr. L. F. Curtiss, from *Scientific Monthly* for November 1928. Reader, F. Johnson, student;

Magnet Defies Gravitation, from *Science & Invention*, March. Reader, Eitaro Etow, student, and

Insulation. The Opportunity for Research, by J. B. Whitehead, from A. I. E. E. JOURNAL, January 1929. Reader, R. H. Crumley, student. February 14. Attendance 75.

Forces on Magnetically Shielded Conductors, by J. H. Morecroft, and Alva Turner, from A. I. E. E., JOURNAL, January 1929. Reader, Homer A. Morton, student;

The Milwaukee Electric Passenger Locomotives, by Lowell Kurtz, student, and

Electrical Timing on Race Tracks, from January *Motor World*. Reader, Bruce Mull, student. February 21. Attendance 80.

Graphic Instruments Search Out Power Faults, by R. S. Werthheim and W. D. Riggs, from *Power Magazine*, February 16, 1929. Reader, A. W. Greiner, student;

Uses of Radio as an Aid to Air Navigation, by J. H. Dellinger, from A. I. E. E. JOURNAL, February 1929. Reader, E. F. Sauke, student, and

"Shotgun" Fuse Solves High-Tension Problems, by J. P. Medlin, from *Electrical World*, February 23, 1929. Reader, Fred Sugiura, Student. February 28. Attendance 79.

University of Nebraska

Inverted Speech, Delayed Speech, Mechanical Larynx and Synthetic Lung, by S. P. Grace, Asst. Vice-President, Bell Telephone Laboratories, Inc. February 14. Attendance 35.

Temperature Measuring Devices, by Dan McQuaid, Taylor Instrument Co. Joint meeting with A. S. C. E. Chapter and A. S. M. E. Branch. February 27. Attendance 100.

Bakelite—A Research of Synthesis, by R. C. Shney, Research Engr., Bakelite Corp. Illustrated. Banquet, sponsored by Lincoln Engineers Club. March 6. Attendance 65.

Newark College of Engineering

The Interconnection of Power Systems, by C. S. Gray, student, and

The Clark Thread Company's Power Plant, by L. M. Klenk, student. February 25. Attendance 24.

Telephone Central Office Power Plant Equipment, by E. J. Lott, student, and

Interconnections of Power Systems, by C. M. Stuehler, student. Business session. Inspection trips were discussed and the treasurer's report was read and accepted. Pictures of the ship *California* were shown. March 4. Attendance 24.

University of New Hampshire

The Magnetic Blow-Out, by J. W. Theall, student, and

Measurement of High-Voltage Disturbances, by J. F. Tinker, student. February 9. Attendance 30.

The Electric Phonograph, by J. C. Terry, student;

Radio as an Aid to Air Navigation, by A. K. Whitcomb, student, and

Thermal Overload Protection for A. C. Motors, by G. W. Withington, student. February 23. Attendance 27.

My Summer's Work—and the Apprentice System of the N. Y., N. H. & H. R. R., by W. R. Wood, student;

The Shaded Magnetic Field, by K. E. Wheeler, student, and

Causes of Irregular Wave Form in an Alternator, by R. W. Adams, student. March 2. Attendance 30.

College of the City of New York

Business meeting. February 21. Attendance 18.

The Method of Standardizing Gasoline for Automobiles with Tetra-Ethyl Lead, by Dr. Graham Edgar, Ethyl Gasoline Corp. Joint meeting with A. S. M. E. and A. I. Ch. E. Branches. February 28. Attendance 70.

Inspection trip to Lehn & Fink, Inc., Bloomfield, N. J. March 8. Attendance 27.

New York University

The Gas-Electric Bus, by George Berggren, student, and

The Effects of Electrolysis on Gas and Water Mains, by Frank Goss, student. December 10. Attendance 23.

The Arc Light, by Harold Torgersen, student, and

Spot Welding and Its Application, by C. Iserman, student. January 10. Attendance 18.

The Gyrocompass, by Mr. Streicher, student;

The Evils of a Low-Power Factor, by Mr. Schmidt, student, and

Transmission Structures, by Mr. Meagher, student. February 13. Attendance 19.

The Fundamental Principles of Television, by Mario Banfi, student;

The Methods Used to Safeguard the Millions of Passengers on the Railroads of the United States, by Kenneth Estler, student, and

An Economic Consideration of the Use of Electricity for Cooking Purposes, by W. Conron, student. February 27. Attendance 21.

University of North Carolina

Work with Duke Power Company, by W. B. White, student, and

Work with the Tidewater Power Company and the Testing of House Meters, by E. R. Davis, student. The following officers elected: President, W. B. Sharp; Vice-President, H. J. Hines, Jr.; Secretary, E. T. Gross, Jr.; Treasurer, W. B. Massenburg (re-elected). February 14. Attendance 18.

The History of Radio, by H. W. Arlin, Personnel Director, Mansfield Plant, Westinghouse Electric & Mfg. Co., and

Student Engineers with General Electric Co., by H. J. Wheeler, February 28. Attendance 30.

University of North Dakota

Modern Electrical Railways, by Burke Bair, student, and

The Business Side of Engineering, by Gustave Glass, student. December 13. Attendance 20.

Still-film "Air Port Lighting." February 7. Attendance 20.

Talking Movies, by Charles Brietweiser, student, and

Magnetically Shielded Conductors, by Charles Powell, student. Discussion of plans for Engineers Day. February 14. Attendance 22.

Construction Problems, by C. H. Van Petten, Construction Engr., Demers Bridge. February 20. Attendance 51.

Northeastern University

Inspection trip to Simplex Wire and Cable Company. Following the tour several high-tension tests were exhibited in the electrical research laboratory. February 16. Attendance 62.

Ohio Northern University

High-Speed Circuit Breakers, by R. F. Rice, President. Plans were completed for holding the Engineers Week. February 7. Attendance 18.

Ohio State University

Value of Public Speaking to the Engineer, by R. E. Knox, student, and

Electric Railways, by E. S. Gunn, General Electric Co. Illustrated. February 7. Attendance 45.

Cosmic Rays, by H. F. Blake, student. Prof. F. C. Caldwell was presented with a cup as a token of appreciation of the work he has done as Counselor of the Branch. Motion picture—"The Single Ridge." Talk was given by C. S. Coler, Manager, Educational Dept., Westinghouse Electric & Mfg. Co. Election of officers. February 28. Attendance 55.

Oklahoma A. & M. College

Motion pictures—"Power Transformers" and "I See You Calling Me." February 13. Attendance 12.

University of Oklahoma

State Line Power Plant, by R. W. Coursey, student;

Western Electric Plant, by LeRoy Moffett, student;

Radio Station WENR, by E. P. Shultz, student;

Chicago Municipal Air Port, by Bill Woods, student, and

Keokuk Power Plant, by Charles Ittner, student. February 14. Attendance 27.

Business meeting. March 7. Attendance 20.

Oregon State College

Present Day Vitaphone and Movietone Equipment, by A. L. Albert, Instructor in Elec. Engg. February 11. Attendance 66.

Inspection of Vitaphone and Movietone Equipment at the Whiteside Theatre. February 13. Attendance 63.

Film—"Power Transformers." Explanatory comments were made by E. C. Starr, Instructor in Elec. Engg. February 18. Attendance 62.

Safety Engineering, by John B. Fisken, Consulting Engr., Washington Water Power Co. G. E. Quinan, Vice-President, District No. 9, spoke on the Institute and related activities. February 19. Attendance 38.

Pennsylvania State College

Two Summers in Alaska, by B. L. Robertson, Elec. Engg. Dept. Prof. L. A. Doggett discussed the Regional Convention to be held in Cincinnati, March 20-23. February 13. Attendance 75.

University of Pennsylvania

Opportunities of the Engineer in Industry, by H. D. James, Consulting Control Engr., Westinghouse Electric & Mfg. Co. A few remarks were also made by A. M. Dudley, Engg. Supervisor of Development of the same company. February 13. Attendance 36.

Fifth Annual Banquet. Talks were given by the following: W. R. Whitney, Director of Research, General Electric Co.; W. F. G. Swann, Director of the Bartol Laboratory of Franklin Institute, and Harold Pender, Dean of the Moore School of Electrical Engg. February 20. Attendance 100.

Purdue University

The Photoelectric Cell in Communication, by Dr. J. O. Perrine, American Tel. & Tel. Co. Illustrated with slides and talking pictures. February 25. Attendance 450.

Rhode Island State College

Electric Tug Boats, by Harold Gerlack, student, and

S. S. California, by Joseph Disano, student. February 15. Attendance 26.

Smoker. Prof. William Anderson and Dean R. W. Wales spoke on the advantages of participation in the activities of the A. I. E. E. February 20. Attendance 19.

Radio Communication on Trains, by Nicholas Abbenante, student, and

Television, by Edward Aceton, student. March 1. Attendance 16.

Rose Polytechnic Institute

Light and Vision, by W. E. Dodson, student, and

Lighting and Its Relation to the Industries, by F. O. Andrews, student. Slides. February 21. Attendance 37.

Heaviside's Method of Mathematical Analysis, by Prof. H. R. Mason. March 7. Attendance 37.

Rutgers University

Surge Impulse Breakdown of Air, by W. Dalton, '29, and

A-C. Filter Circuits, by E. Wilson, '29, February 5. Attendance 22.

High-Speed Circuit Breakers in Electric Railways, by W. Breazeale, '29, and

Ground Detection in Isolated D. C. and A. C. Circuits, by Mr. Wolfe, '29. February 12. Attendance 22.

Deion Circuit Breakers, by Mr. Sherbo, '29, and

Recent Improvements of Turbo-Generators, by Mr. Walton, '29. February 19. Attendance 22.

South Dakota State School of Mines

Work of the Telephone Laboratories, by G. E. Bickley, Division Personnel Supervisor, N. W. Bell Tel. Co. February 25. Attendance 40.

University of South Dakota

Amateur Photography, by Orla Bendixen. February 11. Attendance 12.

Business Meeting. The following officers were elected: Chairman, Enar Johnson; Vice-Chairman, H. Scholes; Secretary, E. E. Lovejoy; Safety Council Chairman, P. Miller. Committees were also appointed as follows: Lodging—Mr. Dickinson; Inspection Trip—Mr. Crosby, and Entertainment—Mr. Johnson. February 25. Attendance 14.

Stanford University

Automatic Electric Welding, by Mr. Owens, General Electric Co. Illustrated with motion picture. Mr. Brown of San Francisco exhibited some slides showing the welding problems encountered in a job shop. Joint meeting with A. S. M. E. February 7. Attendance 45.

Telephoto, by L. A. Gary, Pacific Telephone & Telegraph Co. Illustrated.

Broadcasting Equipment, by C. S. Smith, Jr., of the same Company. Illustrated. February 27. Attendance 100.

Inspection of the telephoto and broadcasting equipment in the Grant Avenue Exchange of the Telephone Company in San Francisco. March 2. Attendance 23.

Stevens Institute of Technology

Smoker. Talks on "The Smoke Nuisance" were given by H. N. Davis, President, Stevens Institute, Dr. Darlington and Samuel Frontz. Demonstration of photographic apparatus, electrically operated. Film—"Promotion of the Engineering Congress at Tokio, Japan." Joint with A. S. M. E. March 6. Attendance 70.

Texas A. & M. College

Reproduction of Sound and Scene, by J. L. Gatlin, student. The following pictures were shown: "Magic of Communication." "Western Electric," "The Telephone Repeater," "The Electric Transmission of Speech." H. W. Whitney, with the assistance of C. S. Robinson, students, demonstrated the effect of cutting out various frequencies of voice and music by filters. February 22. Attendance 86.

University of Texas

Film—"Power Transformers." Plans were discussed for an inspection trip to the power plant of the Texas Power and Light Co. February 14. Attendance 23.

Electrolysis in Power Distribution Systems, by Professor Ramsey. Plans for the Regional Meeting to be held in Dallas, May 7-9, discussed. February 28. Attendance 18.

University of Utah

Movietone, by Lorin Moore, student. February 12. Attendance 14.

University of Vermont

The Conowingo Development, by D. S. Chamberlain, '29. February 12. Attendance 15.

Opportunities for Employment in The Bell System, by C. E. Brown, '28. A combined report on "Theory, Operation, and Testing of the Deion Circuit Breaker" was given by A. E. Merrill, '30, R. A. Dailey, '30, and F. E. Beckley, '30. February 27. Attendance 18.

Washington State College

Westinghouse East Pittsburgh Works, by Prof. H. F. Lickey. Program and Membership Committees appointed. February 13. Attendance 20.

University of Washington

Sidelights on Einstein's Theory of Relativity, by J. E. Maynard, student. February 1. Attendance 19.

A Few More Waves, by L. A. Meacham, student. Illustrated by means of a violin string. February 8. Attendance 18.

The Life of Michael Faraday, by J. A. Renhard, student. February 15. Attendance 13.

Business Meeting. Discussion of plans for joint meeting with the Seattle Section. March 8. Attendance 12.

West Virginia University

Making the Small Turbine Safe, by C. A. Bowers, student; *Electrification of French Railways*, by G. D. Burner, student; *Automatic Brake Control for Super-Synchronous Motors*, by G. H. Hollis, student; *Radio Aid to Air Navigation*, by W. S. Bosely, student; *Frequency Control for Broadcasting*, by C. B. Seibert, student, and *Standardization of Electrical Measuring Instruments*, by J. R. Nottingham, student. February 18. Attendance 18.

Elevator Motors, by O. R. Allen, student; *Electric Trolley in Foundry*, by G. C. Barnes, student; *Shotgun Fuse for High-Tension Service*, by S. N. Gidding, student; *Influence of Atmospheric Conditions on High-Tension Insulators*, by E. M. Hansford, student, and *Electric Marine Equipment*, by J. Kayuha, student. February 25. Attendance 20.

The Influence of Glaze on Insulator Strength, by R. H. Pell, student; *The Tendency in the Design of Portable Instruments*, by W. H. Ross, student; *The Great Northern Railway Electrification across the Cascade Mountains*, by W. C. Warman, student; *Radio Telephone Used on Railways*, by Frank Watson, student, and *Parasites of the Electric Contracting Industry*, by V. O. Whitman, student. March 4. Attendance 19.

Worcester Polytechnic Institute

The Underlying Principles of Television, by Dr. J. O. Perrine, American Tel. & Tel. Co. Illustrated. February 13. Attendance 130.

Westinghouse Production Methods, by H. C. Bates, '29;

Laying Out Power Lines, by A. C. Halt, '29, and

Experiences with N. Y. Edison Company, by C. L. Robinson, '29. Election of officers. March 5. Attendance 35.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these Founder Societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES, Feb. 1-28, 1929

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

AEOLUS; OR, THE FUTURE OF THE FLYING MACHINE.

By Oliver Stewart. N. Y., E. P. Dutton & Co., 1928. 91 pp., 6 x 4 in., cloth. $1.00.

A brief discussion of the future of civil and military flying machines and of the airship. The author has decided views on many disputed points, and his little essay will interest every one connected with aviation.

AEROPLANES, SEAPLANES, AND AERO ENGINES.

By Capt. P. H. Sumner. Lond., Crosby Lockwood & Son, 1929. (Science of Flight, v. 2). 292 pp., illus., 9 x 6 in., cloth. 25s.

After a historical introduction, this book discusses the principles of aerodynamics, the airscrew, types of engines, the general design and construction of aircraft, rigging, modern types of aeroplanes and seaplanes, and aeronautical instruments. The book is descriptive rather than theoretical, but contains a large amount of information on current craft, and is profusely illustrated.

Bauelemente der Feinmechanik.

By O. Richter. Berlin, V. D. I. Verlag, 1929. 576 pp., illus., tables, 10 x 7 in., bound. 29.-r. m.

This volume is a first attempt to provide the instrument maker with a systematic presentation of the elements of instruments, similar to the well-known books on the elements of machines. It treats successively of the materials used, connections, bearings, driving mechanisms and regulating devices, giving descriptions of a great variety of practical methods, with the necessary data for the designer.

The book will be valuable to manufacturers and designers of typewriters, sewing machines, phonographs, meters, optical instruments and similar apparatus.

Bibliography of Metallic Corrosion comprising references to papers on ferrous and non-ferrous corrosion (including methods of protection) published up to the end of 1927. Greatly enlarged from a bibliography prepared for the British Non-ferrous Metals Research Association and privately issued to its members.

By W. H. J. Vernon. Lond., Edward Arnold & Co., [N. Y., Longmans Green & Co.] 1928. 341 pp., 9 x 6 in., cloth. $8.40.

This bibliography is the work of a skilled investigator of corrosion, who has brought to its compilation and annotation unusual qualifications for the task. The result is a work that will prove indispensable to practically every one in the metal industries or interested in the preservation of metal structures.

The bibliography is arranged chronologically under four topics; the types of corrosion and the factors influencing it, the corroding medium, the metal or article corroded, and protective methods. Numerous annotations and introductory notes are given, and there are sufficient cross references. Over 3800 entries are included.

Bridge and Structural Engineers' Handbook.

By Adam Hunter. 2nd edition. Lond., E. & F. N. Spon; N. Y., Zpon & Chamberlain, 1928. 345 pp., diagrs., tables, 9 x 5 in., cloth. 21s.

This desk reference book, popularly known as "Arrol's handbook," embodies the practise of Sir William Arrol and Company, Ltd., of Glasgow. The scope of the work is indicated by the title. It gives the formulas and data commonly needed by the designer in the form most convenient for office use, and embodies the results of long practical experience in construction.

Bureau of Chemistry and Soils.

By Gustavus A. Weber. Balt., Johns Hopkins Press, 1928. (Institute for government research. Service monographs . . . no. 52) 218 pp., 9 x 6 in., cloth. $1.50.

A careful account of the history of the Bureau of Chemistry, of the work that it does and of the organization of its forces. The book is entirely descriptive and is based on official documents.

Comprehensive Treatise on Inorganic and Theoretical Chemistry, v. 9.

By J. W. Mellor. Lond., & N. Y., Longmans, Green & Co., 1929. 967 pp., diagrs., 10 x 6 in., cloth. $20.00.

The ninth volume of Dr. Mellor's great work is devoted to arsenic, antimony, bismuth, vanadium, columbian, and tantalum. The plan and high standard of the preceding volumes are maintained. For each metal, the history, occurrence, extraction, and properties are discussed, and its important compounds are described in some detail. No other work in English comes so near to filling all the ordinary needs of the chemist, nor does any other contain such exhaustive bibliographies for further information. It is indispensable as a reference work.

Electrical Engineering Problems. Pt. 2; A-c. circuits and Apparatus.

By John G. Pertsch, Jr. N. Y., McGraw-Hill Book Co., 1929. 105 pp., diagrs., 9 x 6 in., cloth. $2.00.

A companion to the author's volume of problems on direct-current circuits. The book contains a classified series of problems, typifying actual practise, intended to give the student practise in application of the fundamentals of the subject.

Engineering English.

By John Hubert Scott. N. Y., John Wiley & Sons, 1928. 321 pp., 9 x 6 in., cloth. $2.75.

This is an interesting and unusual book. Professor Scott presents a course in composition, covering two semesters, which is carefully planed to train the student to express his ideas accurately and correctly, in a pleasing manner. The presentation of the material is unusually definite and complete, due attention is given to matters of mechanical form, and much general information on the correct use of English is included. The book will be helpful to every writer.

An Etymological Dictionary of Chemistry, & Mineralogy.

By Dorothy & Kenneth C. Bailey. Lond., Edward Arnold & Co.; N. Y., Longmans, Green & Co., 1929. 308 pp., 9 x 6 in., cloth. $10.00.

The reader who is curious about such things will find here the derivation of chemical and mineralogical names that have been current in the literature of the period beginning with the middle of the nineteenth century. Each word is defined briefly, and the authority for the derivation given.

Evolutions of the Igneous Rocks.

By N. L. Bowen. Princeton, Princeton University Press, 1928. 334 pp., diagrs., tables, 9 x 6 in., cloth. $5.00.

Dr. Bowen's book is an attempt to interpret the outstanding facts of igneous-rock series as the result of fractional crystallization. He collects the facts that have been determined by the laboratory investigations of silica melts and shows how they can be made to explain the derivation of the igneous rocks. The book is based on lectures given to advanced students of geology at Princeton, but presents an expanded view of the topic.

Exhaust Steam Engineering.

By Charles S. Darling. N. Y., John Wiley & Sons, 1929. 431 pp., illus., diagrs., tables, 9 x 6 in., cloth. $7.50.

An extended presentation of methods for utilizing waste heat by back-pressure engines, exhaust-steam turbines, steam accumulators, and distribution systems. The author writes from the point of view of the user rather than from that of the manufacturer. His aim is to cover the problems associated with th choice of machinery and the disposition of plant in a manner that will enable the owner to ascertain that he is utilizing his fuel to the best advantage.

History of Physics.

By Florian Cajori. Revised and enlarged ed. N. Y., Macmillan Co., 1929. 424 pp., illus., 8 x 5 in., cloth. $3.50.

Traces the development of physics from the beginning of history to the present day and presents a clear picture of the way in which current views have evolved and of the noted physicists of all ages. The new edition has been revised and extended to include recent discoveries.

Mathematical Tables & Formulas.

By Percey F. Smith and William Raymond Longley. N. Y., John Wiley & Sons, 1929. 66 pp., 8 x 5 in., fabriboid. $1.60.

A collection of the tables and formulas most used in solving the numerical problems given in college courses in trigonometry, analytic geometry, calculus, and mechanics.

Modern "Divining Rods."

By R. J. Santochi. 2nd edition. Glen Ellyn, Ill., The Author, 1928. 80 pp., illus., 9 x 6 in., paper. $2.00.

A curious collection of notes on useful and worthless devices for locating ore bodies, hidden metals, etc.

Organometallic Compounds, Pt. 1; Derivatives of the Elements of Groups I to IV.

By Archibald Edwin Goddard and Dorothy Goddard. (Text-Book of Inorganic Chemistry, v. 11; edited by J. Newton Friend) London, Charles Griffin & Co.; Phila., J. B. Lippincott Co., 1928, 418 pp., tables, 9 x 6 in., cloth. $14.00.

In this, the first portion of the final volume of this textbook, we have an extensive account of the organometallic compounds of groups 1 to 4 of the Periodic classification. Approximately 2300 compounds are described, and detailed methods for preparing all for preparing all key compounds are given. Ample references are given to sources of information that supplements the concis accounts of the text. The book treats of a class of compounds concerning which few monographs exist.

Precis de Construction, Calcul et Essais des Avions et Hydravions.

By J. Guillemin. Paris, Gauthier-Villars et cie., 1929. 442 pp., illus., tables, 10 x 7 in., paper. 100 fr.

A handbook for designers and builders, which gives concisely a great amount of data in practical form.

The author first treats of materials, describing their properties, uses and the standards of use. The forms of airplanes, their construction and the construction of their parts are then treated, after which the design of aircraft is treated in detail. Finally, methods of testing are given.

DER QUECKSILBERDAMPF-GLEICHRICHTER, v. 2; KONSTRUKTIVE GRUNDLAGEN.

By Kurt E. Müller-Lübeck. Berlin, Julius Springer, 1929. 350 pp., illus., diagrs., 9 x 6 in., bound. 42.-r. m.

Having considered the theory of mercury arc rectifiers very fully in his first volume, Mr. Mueller devotes the second to their construction. He first discusses the principles of design, giving chapters on voltage characteristics, wave characteristics, power characteristics, and the short-circuit current, and following these with a discussion of design itself. Following this he takes up questions of construction and of the erection of rectifier installations. The final chapter is a description of the great rectifying station of the Berlin railroads.

THE RADIO INDUSTRY; the story of its development as told by leaders of the Industry.

Chic., & N. Y., A. W. Shaw Co., 1928. 330 pp., illus., 9 x 6 in., cloth. $5.00.

The eleven lectures here collected were delivered at the Harvard Graduate School of Business Administration during 1927 and 1928. They include a history of radio development, by David Sarnoff, an account of radio in the World War and of the organization of an American owned transoceanic service, by General Harbord, radio telephony by Doctor Jewitt, the law of the air by Judge Davis, the early history of broadcasting by H. P. Davis, the development of national broadcasting by M. H. Aylesworth, radio merchandising, by J. L. Ray, radio advertising by Pierre Boucheron, and industrial applications of radio by H. C. Weber.

THE ROLE OF SCIENTIFIC SOCIETIES IN THE SEVENTEENTH CENTURY.

By Martha Ornstein. Chicago, University of Chicago Press, 1928. 308 pp., 9 x 6 in., bound. $3.00.

It was during the seventeenth century that the experimental method of studying science was introduced, and the change was due, not to the universities, but rather to the work of independent workers banded together in scientific societies. The present book is intended to show how science advanced during that century, what part was played by individual scientists, and what was done by societies in Italy, England, France, and Germany. The beginning of the scientific journals are traced, and the attitude of the universities toward the experimental sciences is discussed.

SALTS, ACIDS AND BASES; Electrolytes; Stereochemistry.

By Paul Walden. N. Y., McGraw-Hill Book Co., 1929. (George Fisher Baker Non-resident lectureship in chemistry) 397 pp., port., tables, 9 x 6 in., cloth. $4.00.

These lectures were delivered at Cornell University in 1927-28. They deal with the three branches of science in which Dr. Walden has been especially interested; the history of chemistry, electrochemistry and stereochemistry.

An introductory lecture on the lessons that modern chemistry can learn from alchemy is followed by lectures on salts, acids and bases, on electrolytes and non-electrolytes, on the electrical conductivity of non-aqeous solutions and on stereochemistry and optical inversion. The historical development is emphasized in each case, in an interesting way.

SOURCE BOOK IN ASTRONOMY.

By Harlow Shapley and Helen E. Howarth. N. Y., McGraw-Hill Book Co., 1929. (Source books in the history of the sciences). 412 pp., illus., ports., 9 x 6 in., cloth. $4.00.

The contributions of great workers of the past in science are often inaccessible to most students, and as a result his knowledge of their work is based on the secondary accounts given in textbooks. The present series, of which this is the first volume, is intended to remove the difficulty by providing, in convenient form, the most significant passages from the works of the most important sciences during the last three or four centuries. The series is endorsed by a number of the leading scientific societies.

The volume on astronomy contains excerpts from the work of sixty men, starting with Copernicus and ending with G. H. Darwin. All contributions are given in English.

STAGE LIGHTING.

By Theodore Fuchs, Bost., Little, Brown & Co., 1929. 500 pp., illus., 10 x 7 in., cloth. $10.00. (Gift of author).

This work should give great satisfaction to every one interested in stage lighting, whether he be a professional play producer, or amateur, or an illuminating engineer. The functions of stage lighting and the methods of producing desired effects are discussed fully, and in addition there is detailed, sound information upon the electrical equipment in use and the method of controlling it. Attention is paid to the needs of the amateur; by providing directions for designing and building equipment suited to his resources. The subject is treated with great clearness and the book is unusually comprehensive in scope.

STEAM, AIR, AND GAS POWER.

By William H. Severns and Howard E. Degler. N. Y., John Wiley & Sons, 1929. 425 pp., illus., tables, 9 x 6 in., cloth. $4.00.

An elementary text on heat engineering, for courses of limited duration. It aims to describe briefly and clearly typical and representative equipment, and to explain the theory of such machines and devices. The mathematical calculations involved are of the simplest order.

STEAM TURBINES.

By James Ambrose Moyer. 6th edition. N. Y., John Wiley & Sons, 1929. 557 pp., illus., plates, diagrs., tables, 9 x 6 in., cloth. $4.50.

In the new edition of this well-known text, special attention has been given to the calculations for the designing of steam turbines. New sections have been added upon the enlarged field of application of bleeder turbines, upon recent data on the variation of steam consumption with the age of turbines, upon various designs of packing, and upon new features in the design of large high-pressure turbines. An appendix contains the calculations for the design of a reaction steam turbine.

STRENGTH OF MATERIALS.

By Alfred P. Poorman. 2d edition. N. Y., McGraw-Hill Book Co., 1929. 343 pp., diagrs., tables, 9 x 6 in., cloth. $3.00.

This textbook by the Professor of Applied Mechanics at Purdue University is a companion to his "Applied Mechanics," and is intended for use by undergraduate students with a knowledge of physics, the calculus, and statics.

This new edition has additional matter on sudden and impact loads on beams, riveted joints, timber beams, and columns, and on safe stresses for timber.

VERSTARKERMESSTECHNIK; Instrumente und Methoden.

By Manfred von Ardenne. Berlin, Julius Springer, 1929. 235 pp., illus., diagrs., 10 x 7 in., paper. 22,50 r. m.

Discusses methods and apparatus for the accurate measurement of the efficiency of amplifiers. Methods are given in detail for measuring all the important characteristics, and the sources of possible error are pointed out. A bibliography is included.

VORLESUNGEN UBER DIFFERENTIAL-UND INTEGRALRECHNUNG, v. 2; Funktionen Mehrerer Veränderlicher.

By R. Courant. Berlin, Julius Springer, 1929. 360 pp., 9 x 6 in., cloth. 18,60 r. m.

The concluding volume of Professor Courant's textbook treats of functions with several variables. As in the first volume, his aim has been to present the principles and methods clearly and to emphasize their practical applications.

DER WARMEUBERGANG BEIM KONDENSIEREN VON HEISS UND SATTDAMPF.

By M. Jacob and S. Erk; also Die Verdampfungswärme des Wassers und das Spezifische Volumen von Sattdampf für Temperaturen bis 210 deg. C. By M. Jakob. (Forschungsarbeiten, heft 310) Berlin, V. D. I. verlag, 1928. 19 pp., diagrs., tables, 12 x 9 in., paper. 3.50 r. m.

Although steam is our most important technical conveyor of energy, but little is yet known about some of its properties, because of the difficulty of experimental investigation of them. This is true, for example of the process of condensation, which is so incompletely understood that it has been uncertain whether superheated or saturated steam is most effective in this case as a heat carrier. The first report in this pamphlet describes a study of the comparative values of the two, the conclusion being that they are equally efficient, if the steam condenses.

The second report is on a study of the heat of vaporization of water, and gives the results obtained between 30 deg. and 210 deg. cent.

WHAT ENGINEERS Do; an Outline of Construction.

By Walter D. Binger. N. Y., W. W. Norton & Co., 1928. 259 pp., illus., 8 x 5 in., cloth. $2.75.

Not only boys, but also many adults, will be interested in this popular account of the work of the civil engineer. The author, a practising engineer, tells how bridges and buildings, highways and railroads are built, how land is surveyed and mapped, how floods are controlled and water utilized. An unusually good attempt at popularization.

WIE TECHNIK DIR IM HAUSHALT HILFT.

By C. Säuberlich. Berlin, V. D. I. Verlag, 1928. 119 pp., illus., 8 x 6 in., paper. 4.80 r. m.

Explains the principles and construction of the technical appliances used in the household. Heating and ventilating apparatus, gas and electric cooking devices, washing, and ironing machines, refrigerators, lamps, and minor devices are described in simple language.

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contributions from the societies and their individual members who are directly benefited.

Offices:—31 West 39th St., New York, N. Y.,—W. V. Brown, Manager.

1216 Engineering Bldg., 205 W. Wacker Drive, Chicago, Ill., A. K. Krauser, Manager.

57 Post St., San Francisco, Calif., N. D. Cook, Manager.

MEN AVAILABLE.—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to **EMPLOYMENT SERVICE, 31 WEST 39th Street, New York City,** *and should be received prior to the 15th day of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary: temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

POSITIONS OPEN

ELECTRICAL ENGINEER, graduate, for electrical engineering department of school of technology beginning next September. Previous teaching experience not essential. Salary about $2700 for academic year. Advancement and permanency. Apply by letter giving full personal and professional particulars. Photograph desirable. Location, New York. X-7523.

ELECTRICAL ENGINEER, young, graduate, with one or two years' experience for high-voltage transmission investigation. Experience with Cathode-Ray Oscillograph desirable. Apply by letter. Location, Pennsylvania. X-7504.

ENGINEERS, who have had extensive practical experience in precision, electrical and physical measurements. Technically trained men who can show a definite aptitude for laboratory and development work and who can develop along engineering or executive lines, desired. Range of work covered is very broad. Apply only by letter. Location, Massachusetts. X-7537.

ELECTRICAL ENGINEER, to design line of small low-voltage motors. Must be thoroughly familiar with modern production testing and inspection methods. Apply by letter, stating salary expected. Location, Middle West. X-7376-R-356-C.

TECHNICAL GRADUATE, with experience in electrical laboratory on conventional electrical research and theory. Apply by letter. Location, New Jersey. X-7446.

ELECTRICAL ENGINEER, Graduate who has had five or six years' experience in designing power stations and high- and low-tension substations. Apply by letter. Location, New England. X-7223.

MECHANICAL ENGINEER, 28-35, thoroughly experienced in designing small automatic machinery, with college mechanical training and thorough shop experience. Opportunity. Apply by letter, state age, experience and education; also, minimum salary expected. Location Middle West. X-7447-C.

DISTRIBUTION ENGINEER, electrical engineer, with 4-6 years' experience for making distribution surveys on medium size public utility companies, making the necessary computations and preparing plans for the revamping and improving of such systems. Apply by letter. Location, New England. X-7266.

SALES ENGINEER, 1927 or 1928 graduate in electrical engineering for commercial side of manufacturing organization, traveling sales work. Opportunity. Location, Middle West. X-7662-C.

MEN AVAILABLE

ELECTRICAL SALES AND CONSTRUCTION ENGINEER, 31, desires connection with reliable company; graduate of two technical colleges with ten years' varied experience; 7½ years with largest electrical manufacturer; graduate student electrical engineering test course; experience in turbine engineering, switchboard; district office and resident agent sales; also, specialty merchandising. C-5618.

ELECTRICAL ENGINEERING GRADUATE, 27, single, good health, desires position with operating or public utilities company. Four years' experience in electrical service and repair work, and five years' business experience devoted largely to selling. Southern location preferred but not essential. C-4828.

ELECTRICAL ENGINEER, married, desires position as design, research or development engineer. Thorough practical experience in power station and transmission lines, in applying laboratory results to practical uses, trained to do systematic work and organizing; possesses sound theoretical knowledge in electromechanics and electrophysics. Speaks German and French. C-693.

COMBUSTION ENGINEER, with technical training and extensive experience in operating pulverized coal, oil and stoker fired plants, desires position where ability along such lines is required. Capable of operating boiler plants of any size, or of designing same. Now Sales Engineer for large corporation but do not like sales work. A-5506.

ENGINEER, 28, single, electrical engineer also member of I. R. E. One year in testing laboratory; five years in radio manufacturing, including design, research and production of parts and complete receivers. Desires to associate with small manufacturer or distributor; might consider investment in proposition having merit. Location, New York City. B-5138.

MECHANICAL AND ELECTRICAL ENGINEER, 39, single; thorough engineering training; 15 years' experience in United States and abroad in research work and generation, distribution, utilization of electric energy in industry, mines, railroads. Economist. Executive ability. Speaks and writes English, German, and French. Location, immaterial. C-2327.

PROFESSOR OF ELECTRICAL ENGINEERING, with over 10 year's experience as head of Electrical Engineering Department in one of the largest engineering colleges and with additional experience in teaching, practical and administrative work, now in Mid West, desires position as teacher or as an educational director in an Eastern State. C-5609.

MEMBER OF THE BAR AND ELECTRICAL ENGINEER, desires position with responsible attorney, firm or corporation. C-5661.

ELECTRICAL, MECHANICAL ENGINEER, University graduate. Twelve years' experience in technical, commercial, production side of profession. Specialized in oil-circuit breakers, apparatus. Executive, inventive ability. Past two years in charge of engineering in well-known firm abroad. Resigning to return to U. S. Desires connection with progressive manufacturing company, public utility. Any location, preferably West or Middle West. C-5652.

ELECTRICAL ENGINEER AND DESIGNER, 31, B. S.; 8 years' experience with public utilities and engineering corporations covering design, specifications and inspection. Speaks German. Desires position as field engineer in New York City or vicinity. C-5473.

ELECTRICAL ENGINEER, 30, married, good personality and executive ability, with eight years' varied experience, including design, test maintenance and inspection power plant equipment. Two years supervising general test of electrical equipment, desires engineering position

with consulting engineer or industrial plant. C-151.

ELECTRICAL ENGINEER, 29, married. Graduate B. S. in E. E. With General Electric Company five years, including apprentice course. Experienced as cost estimator and sales correspondent. Desires connection with manufacturing concern. C-5678.

PLANNING ENGINEER, 33, married; 8 years' electric utility experience, including electrical system planning, preparation reports and improvement budgets, preparation of engineering contracts, supervision of engineering, coordination of activities of several departments, handling of work on account of municipal improvements and assistant to executive. B-9273.

ELECTRICAL ENGINEER, University graduate. Eight years' experience in design and manufacture of d-c. and a-c. motors and generators. At present in charge of complete electrical and mechanical development for midwest concern. Available upon reasonable notice. C-1801.

ELECTRICAL ENGINEER desires position doing research or development work. Thoroughly trained and competent meter engineer. Experienced in combustion and general laboratory and power plant testing. Has been successful along development lines; also, extensive public utility experience. C-5258.

ELECTRICAL ENGINEER, of extensive education and with wide experience in d-c. machine design. A specialist in economical proportioning. C-5701.

UNIVERSITY GRADUATE IN ELECTRICAL ENGINEERING, married, 30; two years' general experience and four years as instructor of electricity and drawing. Desires teaching position or position as a junior engineer. Now employed. B-7028.

ELECTRICAL ENGINEER, 40; married. Experienced in railway, automotive and building maintenance and repair; 14 years in mechanical department of large public utility as assistant superintendent of shops and master mechanic. Lower New England or northern New Jersey preferred. C-5632.

ELECTRICAL ENGINEER, graduated 1915, 35, with wide experience in construction, design and general engineering for power house, transmission, and distribution work; past three years engineer in Power Sales department of large utility corporation, specializing in steel mill applications. Desires connection as assistant electrical engineer with utility corporation or large manufacturing concern. C-5679.

ELECTRICAL ENGINEER, technical graduate, 43, single. General Electric Test, 7 years' experience in power layouts, substation designs, motor installations, wiring diagrams and kindred subjects for factory and industrial plants. Desires position along similar lines or as draftsman in charge of electrical squad. Now employed. Available 30 days. C-5681.

ELECTRICAL ENGINEER, graduate, 30, married, willing to travel. Has had two years' experience on General Electric Test, 1 year sales and contract service experience, three years in the electrical contracting business, and one year on valuation and appraisal work. Desires to enter sales, inspection or installation work. Will be available on short notice. B-9090.

ELECTRICAL ENGINEER, 31, 10 years' experience; two years complete wiring plans, specifications, engineering, correspondence, for light, power and signals on theatres, hotels, office buildings, loft buildings, clubs, etc; one year with electrical contractor on large buildings; desires permanent connection anywhere as designing engineer with architect, or estimating engineer with contractor. B-4217.

PROFESSOR OF ELECTRICAL ENGINEERING. Head of Department in a state university of high standing would consider a change of institution if opportunity and larger income would be available. Seven years' of practical experience as well as excellent liberal and technical training. Good teacher and organizer. Member of honorary and professional societies. C-5710.

ELECTRICAL ENGINEER, 26, married, 1925 graduate B. S. in E. E.; four years' experience public utility; power plant operating, meter department high- and low-voltage testing, rate schedule application; desirous of obtaining designing and construction engineering position with progressive firm. Location preferred, Atlantic Seaboard. C-5682.

ELECTRICAL ENGINEER, 34, married, graduate M. E., Cornell University. General Electric and Westinghouse Test Courses. Five years' experience in power plant construction and operation. Desires connection with industrial concern having its own power plant. Was in charge of 4000-Kw. industrial plant for three years. Available on short notice. C-5721.

MANAGER, experienced in every branch of electric public utility; engineering, construction, sales and management. Well versed on development of industrial power business, production of good service, satisfactory relations with customers and public. Technical graduate. B-7492.

MEMBERSHIP—Applications, Elections, Transfers, Etc.

APPLICATIONS FOR TRANSFER

The Board of Examiners, at its meeting held March 6, 1929, recommended the following members of the Institute for transfer to the grades of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grade of Fellow

DUER, J. V. B., Electrical Engineer, Pennsylvania Railroad, Altoona, Pa.
HAMILTON, GEORGE W., Vice-President in charge of Hydraulic and Electrical Engineering, Middle West Utilities Co., Chicago, Ill.
MOULTROP, IRVING E., Chief Engineer and Asst. Supt. of Construction Bureau, Edison Electric Illuminating Co., Boston, Mass.
SPALDING, SAMUEL A., Chief Engineer, Gibbs & Hill, Pennsylvania Station, N. Y.
SPOONER, THOMAS, Asst. Manager, Research Dept., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
TAPSCOTT, RALPH H., Electrical Engineer, The New York Edison Co., New York, N. Y.

To Grade of Member

ANDERSON, GORDON R., Development Engineer, Fairbanks Morse & Co., Indianapolis, Ind.
ATHERTON, ALBERT, Engineering Assistant, Western Union Telegraph Co., New York.
BROWNELL, FRANK A., High Tension Division Chief, Public Service Elec. & Gas Co., Metuchen, N. J.
BULL, HEMPSTEAD S., Instructor in Elec. Engg., University of Michigan, Ann Arbor, Mich.
CARMICHAEL, ELWOOD T., Engg. Asst., Public Service Production Co., Newark, N. J.
COLEMAN, JAMES O'REILLY, Asst. Engr., National Electric Light Association, New York.
CUNNINGHAM, ALLAN, Manufacturer Marine Auxiliary Machinery, Seattle, Wash.
DAWSON, CECIL, Lecturer in Elec. Engg., Auckland University College, Auckland, N. Z.
DIEDERICH, P., Supt. of Light and Water Depts., City of Glendale, Glendale, Calif.
GEORGE, E. E., Supt. of Elec. Operation, Tennessee Elec. Pr. Co., Chattanooga, Tenn.
JONES, H. RUSSELL, Asst. Supt. and Elec. Engr., Celulosa Cubana, S. A., Tuinucu, Cuba.
LAUNDER, ARTHUR I., Division Traffic Engr., Pacific Tel. & Tel. Co., Seattle, Wash.
LEVY, DAVID H., Elec. Engr., Magnolia Petroleum Co., Dallas, Texas.
LYTLE, JAMES H., Consulting Engr., Staten Island Edison Corp., Staten Island, N. Y.
O'BRIEN, LAURENCE A., Telephone Systems Engg., Bell Telephone Labs., New York.
PULLEN, MYRICK W., Associate in Elec. Engg., Johns Hopkins University, Baltimore, Md.
PUTNAM, RALPH E. A., Transmission Engg., International Tel. & Tel. Co., New York.
QUARLES, DONALD A., Plant Systems Engr., Bell Telephone Labs., New York, N. Y.
RIDDLE, FRANK H., Director of Research, Champion Porcelain Co., Detroit, Michigan.
RIGGS, OLIVER L., Foreman-Underground Dept., Lynn Gas & Elec. Co., Lynn, Mass.
ROGERS, HURLEY T., Asst. Supt., Underground Construction, N. Y. & Queens Elec. Lt. & Pr. Co., Flushing, N. Y.
ROSEBRUGH, DAVID W., Asst. Rate Engr., Central Hudson Gas & Elec. Corp., Poughkeepsie, N. Y.
ST. CLAIR, HARRY P., Asst. to Elec. Engr., American Gas & Elec. Co., New York.
SCOTT, RALPH Y., Supervisor of Toll and Transmission Testing, New England Tel. & Tel. Co., Boston, Mass.
SELS, HOLLIS K., Asst. Transmission and Substation Engr., Public Service Elec. & Gas Co., Newark, N. J.
THERRELL, DANIEL M., Supervisory Dial Service and Radio, Southern Bell Tel. & Tel. Co., Atlanta, Ga.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before April 30, 1929.

Acock, G. W., General Electric Co., Schenectady, N. Y.
Adlington, E. R., Georgia Railway & Power Co., Atlanta, Ga.
Alford, E. L., Bell Tel. Laboratories, New York, N. Y.
Arnold, N., Columbia Engg. & Mgt. Corp., Cincinnati, Ohio
Axelsson, R. V., Byllesby Engineering & Management Corp., Chicago, Ill.
Ballou, H. P., (Member), Dept. of Power & Light, Sebring, Fla.
Bare, W. E., Southern Bell Tel. & Tel. Co., Birmingham, Ala.
Behr, L., Leeds & Northrup Co., Philadelphia, Pa.
Blakeslee, T. M., Los Angeles Bureau of Pr. & Lt., Los Angeles, Calif.
Botts, M. P., Commonwealth Edison Co., Chicago, Ill.
Bowman, J. C., Public Service Electric & Gas Co., Newark, N. J.
Brady, R. A., General Electric Co., Philadelphia, Pa.
Brandenburg, F. E., Western Electric Co., Kearny, N. J.
Brandt, E. S., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Bruzina, R., Cutler-Hammer Mfg. Co., Milwaukee, Wis.
Buck, O. D., Texas Power Corp., Sequin, Tex.
Burgan, K. E., Ohio Bell Tel. Co., Akron, Ohio
Bush, F. P., Victor X-Ray Corp., Los Angeles, Calif.
Butcher, J. H., Michigan Bell Telephone Co., Detroit, Mich.
Cannizzo, M., (Member), Cutler-Hammer Mfg. Co., Milwaukee, Wis.
Capodanno, R. T., Illinois Bell Telephone Co., River Forest, Ill.
Clingerman, R. J., General Electric Co., Erie, Pa.
Copeland, M. W., Luxortone Corp., Inc., Mt. Vernon, N. Y.
Cordier, N. A., Electric Storage Battery Co., New York, N. Y.
Cornelius, C. C., Kansas City Power & Light Co., Kansas City, Mo.
(Applicant for re-election.)
Correia, J. L., 602 West 137th St., New York, N. Y.
Coulehan, G. W., Allis-Chalmers Mfg. Co., Cincinnati, Ohio
Cowan, F. A., (Member), American Tel. & Tel. Co., New York, N. Y.
Coyle, H. F., New York Power & Light Corp., Albany, N. Y.
Curran, G. M., Electric Storage Battery Co., New York, N. Y.
D'Amato, N., 146 E. 129th St., New York, N. Y.
de la Cierva, J., General Electric Co., Schenectady, N. Y.
Dewey, G. W., N. J. Bell Telephone Co., Hackensack, N. J.
Dobson, L. C., Commonwealth Edison Co., Chicago, Ill.
Dowdell, J. R., Houston Lighting & Power Co., Houston, Tex.
Drake, H. N., Victor X-Ray Corp., Los Angeles, Calif.
DuChemin, N. M., General Electric Co., Lynn, Mass.
Dumont, D. P., Indiana General Service Co., Marion, Ind.
Eaglen, E. C., Oliver Iron & Steel Corp., Pittsburgh, Pa.
Edgerton, G. E., (Member), U. S. Army; Federal Power Commission, Washington, D. C.
Falkovich, O. C., C. M. Lovsted & Co., Inc., Seattle, Wash.
Fischer, V. C., Central Catholic High School, Toledo, Ohio
Foerster, J. A., (Member), City of Price Albert, Price Albert, Sask., Can.
Fox, W. S., Stevens & Wood, Jackson, Mich.
Frech, A. D., United Electric Lt. & Pr. Co., New York, N. Y.
Frederick, C. L., Bell Telephone Laboratories, New York, N. Y.
Frye, R. F., Westinghouse Elec. & Mfg. Co., Bridgeport, Conn.
Gallagher, F. J., Bronx Gas & Elec. Co., New York, N. Y.
Gottschau, C. M., Lanston Monotype Machine Co., Philadelphia, Pa.
Gulliksen, F. H., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Gustavsen, E., New York Central Railroad, New York, N. Y.
Haley, W. H., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Hart, L. C., (Member), Hi-Voltage Equipment Co., Cleveland, Ohio
Hazlehurst, C. M., Consulting Engineer, 712 Flat Iron Bldg., Asheville, N. C.
Hollis, I. H., Commonwealth Edison Co., Chicago, Ill.
Howland, E. W., Commonwealth Edison Co., Chicago, Ill.
Hubbard, C. J., Kansas City Power & Light Co., Kansas City, Mo.
Huber, G. H., Bell Telephone Laboratories, Inc., New York, N. Y.
Hunt, F. B., Nazareth Cement Co., Nazareth, Pa.
Ides, X. D., (Member), United Engineers & Constructors, Inc., Philadelphia, Pa.
Intrieri, N., New York Edison Co., New York, N. Y.
Ives, H. E., (Fellow), Bell Tel. Laboratories, Inc., New York, N. Y.
James, R. S., Interborough Rapid Transit Co., New York, N. Y.
Jennings, E. B., Southwestern Bell Tel. Co., Oklahoma City, Okla.
Johnson, W. H., Southeastern Engineering Co., Birmingham, Ala.
Jones, W. C., Toledo Edison Co., Toledo, Ohio
Kezele, M., Union Electric Lt. & Pr. Co., St. Louis, Mo.
Knowlton, J. J., Western Electric Co., Kearney, N. J.
Kraybill, V. H., Public Service Co. of No. Ill., Chicago, Ill.
Kyser, M. W., (Member), American Tel. & Tel. Co., Atlanta, Ga.
Laquidara, A. K., Plasterers Information Bureau, New York, N. Y.
Leazenby, A. L., Michigan Bell Telephone Co., Detroit, Mich.
Lee, Y. W., Mass. Institute of Technology, Boston, Mass.
Leppelman, L., Public Service Dept., Glendale, Calif.
Lowman, A. A., (Member), Northwestern Bell Telephone Co., Omaha, Nebr.
Matlock, L. F., Bureau of Reclamation, Pavillion, Wyo.
McCracken, E. G., Alfred Collyer Co., Toronto, Ont., Can.
McCurdy, R. G., (Member), Graybar Electric Co., Kansas City, Mo.
McDougal, W. L., Pullman Free School of Manual Training, Chicago, Ill.
McNeely, J. H., Clinton Electric Lt. & Pr. Co., Clinton, Conn.
McTaggart, F. E., West Penn Power Co., Pittsburgh, Pa.
Meath, P. L., Texas Construction Co., Houston, Tex.
Meytrott, C. W., Florida Power Corp. & Subsidiaries, St. Petersburg, Fla.
Moosbrugger, F. J., Public Service Co. of No. Ill., Evanston, Ill.
Muir, W., Cornell University, Ithaca, N. Y.
Mulligan, J. F., United Electric Light & Power Co., New York, N. Y.
Mullineaux, F., R. C. A. Photophone Inc., New York, N. Y.
Oldham, E. W., Commonwealth Edison Co., Chicago, Ill.
Paroonagian, L. A., Pennsylvania Railroad, Philadelphia, Pa.
Patton, E. P., Bronx Gas & Electric Co., New York, N. Y.
Person, A. W., Northern Nebraska Power Co., Crete, Nebr.
Petersen, A. H., Westchester Lighting Co., Mt. Vernon, N. Y.
Peterson, A. E., 6110 Rockridge Blvd., North, Oakland, Calif.
Phelps, J. E. B., (Member), Sarnia Hydro-Electric System, Sarnia, Ont., Can.
Phillips, C. A., Virginia Electric & Power Co., Roanoke Rapids, N. C.
Pierce, H. J., (Member), Northwestern Bell Telephone Co., Minneapolis, Minn.
Plummer, E. W., Buffalo General Electric Co., Buffalo, N. Y.
Powell, J. B., General Electric Co., New Haven, Conn.
Racer, T. J., Pacific Tel. & Tel. Co., Stockton, Calif.
Regniere, J. A., Shawinigan Water & Power Co., St. Narcisse, Que., Can.
Rietow, L. A., Pacific Electric Mfg. Corp., San Francisco, Calif.
Rommel, E. J., Toledo Edison Co., Toledo, Ohio
Ross, C. W., Roessler & Hasslacher Chemical Co., Niagara Falls, N. Y.
Ross, L. E., Niagara Falls Power Co., Niagara Falls, N. Y.
Rossiter, H. A., Electric Storage Battery Co., New York, N. Y.
Sammer, B. N., Union Oil Co., Los Angeles, Calif.
Sawford, H. S., American Tel. & Tel. Co., New York, N. Y.
Secrest, W. J., Firestone Tire & Rubber Co., Akron, Ohio
Sheldon, E. E., (Member), Utilities Engineering Co., Inc., Albany, N. Y.
Shermund, R. C., Federal Telegraph Co., Palo Alto, Calif.
Simpson, H. G., Canada Northern Power Corp., Ltd., New Liskeard, Ont., Can.
Smith, R. D., Public Service Co. of No. Ill., Evanston, Ill.
Snow, H. E., (Member), Gibbs & Hill, New York, N. Y.
Soule, F. M., Carnegie Institution of Washington, Washington, D. C.
Stacey, L. B., (Member), University of British Columbia, Vancouver, B. C., Can.
Stevenson, A. C., Hecla Mining Co. & Sullivan Mining Co., Wallace, Idaho
Stewart, L. B., Shawinigan Water & Power Co., Shawinigan Falls, Que., Can.
Stith, R. G., Kansas City Power & Light Co., Kansas City, Mo.
Strelzoff, J. A., 170 Claremont Ave., New York, N. Y.
Taber, L. E., New Bedford Vocational School, New Bedford, Mass.
Talbott, J. E., Stevens & Wood, Inc., Jackson, Mich.
Teare, B. R., Jr., University of Wisconsin, Madison, Wis.
Terkelson, G. A., Atlantic Refining Co., Philadelphia, Pa.
Thibeault, A., Canada Power & Paper Corp., Grande Mere, Que., Can.
Thomas, G. C., Hydro-Electric Power Comm., Toronto, Ont., Can.
Turnbull, A. G., (Member), Commonwealth Edison Co., Chicago, Ill.
Valentine, D. O., American Tel. & Tel. Co., Cleveland, Ohio
Wahlstrom, R. D., Western Union Tel. Co., Chicago, Ill.
Wardner, H. E., 4 Academy St., Saranac Lake, N. Y.
Waring, M. L., General Electric Co., Schenectady, N. Y.
White, E. T., Jr., 9315-107th St., Richmond Hill, N. Y.
Wickstrom, C. S., Commonwealth Edison Co., Chicago, Ill.
Willis, E. S., Bell Telephone Laboratories, Inc., New York, N. Y.
Winemiller, H. R., Commonwealth Edison Co., Chicago, Ill.
Wollaeger, L. A., Globe Electric Co., Milwaukee, Wis.
Wyland, E. E., Mountain States Tel. & Tel. Co., Boise, Idaho
Total 148.

Foreign

Bruford, S. J., (Member), Punjab P. W. Dept., Jogindar Nagar, Kangra District, No. India
Davis, N. E., (Member), Marconi Wireless Telegraph Co., Ltd., Chelmsford, Essex, Eng.
Dean, G. H., Corrie, Old Shoreham Road, Shoreham-by-Sea, Eng.
Husain, Ziarat B., Principal, Electrical Engineering Dept., Jagatjit Birdwood Engg., College, Amritsar; for mail, Allahabad, U. P., India
Josse, H., Ste. Electricite de Paris, Saint Denis, France
Mukerji, K. P., Thana Electric Supply Co. Ltd., Thana, Bombay, India
Mulqueen, B. A., Rio de Janeiro Tramway, Lt & Pr. Co. Ltd., Rio de Janeiro, Brazil, So. America
Pettigrew, J., All America Cables Inc., Cali, Colombia, So. America
Pyper, D., Braden Copper Co., Rancagua, Chile, So. America
Total 9.

STUDENTS ENROLLED

Abella, Roman V., University of Washington
Adams, Eric G., McGill University
Alger, Blandford A., Cooper Union
Anderson, Hugh V., Oklahoma Agricultural & Mechanical College
Anderson, John W. Jr., University of Notre Dame
Angus, F. William, McGill University
Asmus, William F., Armour Institute of Tech.
Austin, Lewis H., Iowa State College
Bacon, Walter M., Cornell University
Badger, Harold R., University of Washington
Bak r, George W., Armour Institute of Tech.
Ballou, Frank M., Iowa State College
Barlow, Robert J., University of Michigan
Bartley, Edward A., University of Notre Dame
Bell, Graham A., Jr., McGill University
Berry, Wayne J., Missouri School of Mines & Metallurgy
Betz, Willie G., Louisiana State University
Beveridge, William B., Newark, College of Eng.
Bigelow, Folger H., Armour Institute of Tech.
Blahna, Charles, Armour Institute of Technology
Blomquist, Sigurd, University of Utah
Boggess, Bill, Kansas State Agricultural College
Bogowicz, Chester S., Armour Institute of Tech.
Bonilla, Charles F., Columbia University
Bossler, Edward C., Montana State College
Braga, Felix J., University of Minnesota
Branson, Harry, Jr., University of Pennsylvania
Brant, T. J., University of Toronto
Braunwarth, William W., University of Penn.
Breneman, Alfred M., Kansas State Agri. College
Brieger, Earl W., University of Notre Dame
Briggs, Maynard R., University of Minnesota
Brown, Homer, University of Minnesota
Browne, Townsend D., Rensselaer Polytechnic Institute
Bruncke, Harry P., University of Minnesota
Buehling, Norman D., Armour Inst. of Technology
Bugenstein, Arthur A., University of Minnesota
Burns, James A., Cooper Union
Carleton, Stephen O., Brown University
Carsberg, Edgar C., University of Minnesota
Causey, Hoyt C., Clemson Agricultural College
Chalek, Isadore, University of Minnesota
Chatfield, Gurdon F., Rensselaer Polytechnic Inst.
Christiansen, John, University of Notre Dame
Cillie, Charl D., Massachusetts Institute of Tech.
Clancy, Thomas, Northeastern University
Clark, Everett O., University of Detroit
Clark, Hardin T., University of Louisville
Clark, William R., University of Pennsylvania
Clarke, Frederick E., McGill University
Clema, John M., University of Nebraska
Cleveland, Arthur L., University of Nebraska
Cline, W. Kenneth, Clarkson College of Tech.
Coats, Arlie, Kansas State Agricultural College
Conger, George B., Jr., Cornell University
Conrad, Warren D., Eng. School of Milwaukee
Converse, Henry A., 3rd, Virginia Polytechnic Institute
Cooney, William F., Clarkson College of Tech.
Cordua, Carl D., College of the City of New York
Cover, Earl J., Kansas State Agricultural College
Cox, Ray D., University of Florida
Crawford, James M., McGill University
Credle, Alexander B., Cornell University
Criswell, William L., Kansas State Agr. College
Crockett, Alton E., University of Maine
Crouter, Leslie E., Montana State College
Curd, John P. Jr., University of Louisville
Curry, Arnet A., Purdue University
Curtis, William G., Oklahoma A. & M. College
Dale, Edwin E., University of Washington
Damaskin, Nicholas J., University of Pittsburgh
Danziger, Samuel, Columbia University
Datshkovsky, Eleazar, Lewis Institute
Davis, George P., University of Nebraska
Davis, Harry V., University of British Columbia
DeBaene, E. C., University of Notre Dame
Defina, Frank P., Northeastern University
Denny, Fred F., University of Arizona
Diedrich, Erwin H., University of Minnesota
Dollenmaier, Jack M., Armour Institute of Tech.
Douglas, Norvel, Kansas University
Douglass, William E., University of Texas
Dudley, Beverly, Armour Institute of Technology
Duffy, John B., Northeastern University
Dunn, Raymond C., Georgia School of Tech.
Dylewski, Thaddeus J., Armour Institute of Tech.
Earl, John C., University of Illinois
Eberts, Hermann L., McGill University
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Ellicock, Albert B., University of Arizona
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DIGEST OF CURRENT INDUSTRIAL NEWS

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Illumination.—Bulletin 500, 24 pp. "Lighting of Modern Office Buildings," Holophane Company, Inc., 342 Madison Avenue, New York.

Network Transformers.—Bulletin 1807, 12 pp. Describes Westinghouse network transformers and accessories for secondary alternating-current network systems. Westinghouse Electric & Manufacturing Co., East Pittsburgh.

Fans.—Bulletins 17-2 to 17-6. A series of 2-page bulletins describing "Century" stationary and oscillating fans; and ceiling fans for alternating and direct current. Century Electric Company, 1827 Pine Street, St. Louis.

Pulverized Fuel Equipment.—Bulletin, 52 pp., describes the Aero Unit System of pulverized fuel firing and covers the development and application of the unit system for firing pulverized fuel. Foster Wheeler Corporation, 165 Broadway, New York.

Cable Accessories.—Catalog 741, 46 pp. Describes "Standard" jointing and miscellaneous materials, including insulating compounds for cable terminals, junction boxes and cable joints, paper jointing tubes, copper connectors, tapes, lead sleeves, etc. Standard Underground Cable Company, 17th & Pike Streets, Pittsburgh.

Power Plant Instruments.—Bulletin, 48 pp., "Power Plant Instrument Data Book." Outlines one hundred and five applications of instruments to the steam power plant for measuring temperatures, pressures, flows, liquid levels and speeds. The Brown Instrument Company, Wayne and Roberts Ave., Philadelphia.

Switching Equipment.—Bulletin 312, 36 pp., with prices effective March 1, 1929. Contains complete engineering data, descriptive information, list of quantity prices of outdoor type standard and switching equipment for 7500, 12,000 and 15,000 volts. James R. Kearney Corporation, 4228 Clayton Avenue, St. Louis.

Automatic Valve Control.—Bulletin, 20 pp. and price list. Describes Bristol's automatic electric control valves, motor operated and magnet types. Applications of such apparatus for fuel, gas, air, steam and water are outlined. Illustrations and brief descriptions of temperature recording instruments are included. The Bristol Company, Waterbury, Conn.

Transformers.—Bulletin 161, 20 pp. Contains instructions for the installation and operation of power and distribution transformers. The bulletin also covers such subjects as location of transformers, their storage, handling and installation; drying core and coils; drying and testing oil; proper operating temperature. Wagner Electric Corporation, 6400 Plymouth Street, St. Louis.

Lightning Protection.—Bulletin C-1737-D, 20 pp., "Effective Lightning Protection." Describes the nature and magnitude of transient voltages on electrical systems, lightning arrester requirements and applications. Of special interest is the information on oscillograph studies of lightning phenomena and the economic value of lightning protection. The oscillograph studies described were made by the Westinghouse Company in the Tennessee mountains on a 154-kv. line of the Knoxville Power Company. Westinghouse Electric & Manufacturing Company, East Pittsburgh.

Twisted Service Cable.—Bulletin, 36 pp. Describes twisted service cable for house service and street lamp connections. It contains a special section on specifications with a detailed table of weights and sizes. Instructions for the proper installation of cable from the poles to the house are illustrated and described. This booklet was edited by W. K. Vanderpoel, vice-president and executive engineer of the Okonite Company, and a recognized authority on outside plant construction. The Okonite Company, Passaic, N. J.

NOTES OF THE INDUSTRY

The Wagner Electric Corporation, St. Louis, has added K. G. Baker to its Cincinnati sales force. Mr. Baker was previously connected with the Century Electric Company and with the Fulton Iron Works.

The Ohio Brass Company, Mansfield, Ohio, has opened a new office at 2143 Railway Exchange Building, 611 Olive Street, St. Louis. This office will be the headquarters of H. W. Kilkenny district sales manager for the company in the St. Louis territory.

Rochester Electric Products Corporation, 87 Allen Street, Rochester, N. Y., manufacturers of the Diverter Pole Generator, described in a paper which was recently published in the JOURNAL, has appointed the H. M. Thomas Company, with offices at 589 Howard Street, San Francisco, and 912 East 3rd Street, Los Angeles, as California sales representative.

General Electric Annual Report for 1928.—Earnings of the General Electric Company for 1928 amounted to $54,153,806, according to the annual report of the company. Orders received during the year 1928 were $348,848,512, compared with $309,784,623 in 1927, an increase of 13 per cent, and unfilled orders at the end of the year were $72,953,000, compared with $68,916,000 at the close of 1927, an increase of six per cent.

The Roller-Smith Company, 12 Park Place, New York, has made the following additions to its sales organization: Jackson Brown, Jr., 701 Kittridge Building, Denver, is representative in Colorado, Utah, Wyoming and northern New Mexico: The Manila Machinery & Supply Company, Inc., Manila, P. I., is representative in the Philippine Islands. Both of these new representatives will handle the Roller-Smith Company's line of electrical measuring instruments, relays and circuit breakers.

The Synthane Corporation has completed the erection of its plant at Oaks, near Philadelphia, and is now in production of laminated Bakelite products in sheets, rods, tubes and fabricated parts. The plant, built solely for the production of laminated Bakelite materials, is of the most modern construction and located on the Pennsylvania Railroad System. The Synthane Corporation is represented by H. G. Blauvelt, Tribune Building, New York; J. B. Rittenhouse, 32-40 South Clinton Street, Chicago, and C. E. White & Company, Bulkley Building, Cleveland.

Westinghouse Electric's Best Year.—The business of the Westinghouse Electric & Manufacturing Company during the year 1928 was the best of any twelve months in its history, according to the company's report recently made public. Sales billed for the year were $189,050,302, and the net income was $20,814,940, which figures exceed previous records by $3,500,000 and $2,700,000 respectively. The value of unfilled orders on December 31, 1928, was approximately $47,000,000. During the latter nine months of the year, the value of orders received exceeded by almost $20,000,000 that of the same period during 1927, due largely to the increased demand for radio products and industrial motor apparatus.

Burndy Engineering Co., Inc., 10 East 43rd St., N w York, manufacturers of equipment for the high tension bus, has appointed the following representatives for their respective territories: Boston, J. J. Costello, 201 Devonshire St.; New York, J. Leo Scanlon, 50 Church St.; Buffalo, J. Leo Scanlon, 487 Ellicott Square; Philadelphia, The Bradley Co., 2401 Chestnut St.; Pittsburgh, Henry N. Muller Co., First National Bank Bldg; Atlanta, H. Douglas Stier, 101 Marietta St.; Cleveland, A. D. Fishel Co., 942 Engineers Bldg.; St. Louis, J. P. Lane, 471 Paul Brown Bldg.; Dallas, Elgin B. Robertson, 711 Southwestern Life Bldg.; Denver, Joy & Cox, Inc., 314 Tramway Bldg.; San Francisco, H. M. Thomas Co., 163 Second St.; Seattle, Fred W. Carlson, 424 Dexter Horton Bldg.; Los Angeles, L. W. Thompson Co., 912 East 3rd St.; Chicago, Frank P. Withers, 2057 Jarvis Ave.

JOURNAL OF THE A. I. E. E

DEVOTED TO THE ADVANCEMENT OF THE THEORY AND PRACTISE OF ELECTRICAL ENGINEERING AND THE ALLIED ARTS AND SCIENCES

The Institute is not responsible for the statements and opinions given in the papers and discussions published herein. These are the views of individuals to whom they are credited and are not binding on the membership as a whole.

Vol. XLVIII MAY, 1929 Number 5

*To the Members of our Student Branches:**

IN a few weeks a large number of you will bid farewell to your Halls of Learning and will begin your active engineering careers. You have spent many years preparing yourselves to be fit and useful citizens. Appreciating that a successful life is one of service you have chosen engineering as the channel through which to serve.

What will be the quality of your service and what satisfaction are you going to get from it? It is a trite saying and true that one gets out of life pretty much what one puts into it.

Your education has aimed to prepare you to add to the richness of life,—your life and your fellows'. If you have become technicians only you are in danger of continuing along narrow lines with a limited outlook. If, on the other hand, you have broadened your viewpoint and your contacts with the humanities without sacrificing the acquirement of the necessary technical foundation, if you have familiarized yourselves with the ideals that have inspired mankind through the ages, if you have developed an appreciation of the beautiful and take an interest in history and art as well as in engineering and economics, then you are indeed well started on the road leading to a balanced and well rounded life. We do not live by bread alone, and a life wrapt up in materialism misses the rich enjoyment that comes from the finer, the cultural and the spiritual contacts.

In selecting the field for your activity after graduation choose that which most appeals to your enthusiasm. There is nothing more sustaining to health and happiness than enthusiasm in work. Study the purpose of your work and learn its particular relation to the rest of the business that you are in, but remember also the importance of knowing how to spend your time when off the job, for your growth still continues after graduation.

You will find your professional interest broadened and increased if you take an active part in an Institute Section. The Institute is organized to help in your development but you must take the initiative. Don't wait for the membership or the attendance committee to find you.

You are now a citizen, one with a special obligation to your fellows due to your education and training. You can pay that obligation only by taking an active interest in the affairs of your community and of your country, and particularly in those affairs where your engineering training gives you a clearer understanding than the general public would naturally have. Here your ability as a convincing speaker, acquired with your studies, will have play and will help you win standing with your fellows.

You are a member of no mean profession. By being a worthy member, broad minded, tolerant and true and using your talents as is expected of an engineer-citizen you will reflect credit on yourself and on your profession and you will have that deep satisfaction which comes from the knowledge that you are helping to move civilization onward and upward.

R. F. Schuchardt

President.

* This month's message is in response to a recommendation made recently by the Student Activities Committee of the Fourth District.

Some Leaders of the A. I. E. E.

Bernard Arthur Behrend was born in Villeneuve, Switzerland, May 9, 1875. He was educated by tutor and studied at the Polytechnic Institute and the University of Berlin. In 1895 he was assistant to the late Gisbert Kapp and in 1896 he became Assistant Chief Engineer to the Oerlikon Company in Switzerland. Thence he came to the United States in 1898, subsequently becoming non-resident lecturer at the University of Wisconsin. In 1899 he became connected with the Bullock Electric Mfg. Co. of Cincinnati, Ohio, as Chief Engineer of its alternating-current work and later, as Chief Engineer of all its plants in the United States and Canada. In 1904 the Bullock Company became allied with the Allis-Chalmers Company and Mr. Behrend became Chief Engineer of the electrical departments of this country, establishing the department in Milwaukee for the manufacture of large units. At the end of 1908 the receivers of the Westinghouse Company engaged Mr. Behrend and members of his staff to take charge of the power engineering department at East Pittsburgh. Remaining connected with these interests for eighteen years, he devoted himself to general consulting work in Boston.

In 1896 Mr. Behrend published his first paper on the circle diagram of the induction motor, which has since been generally adopted in the form in which he first gave it thirty-three years ago. It formed the subject of his Wisconsin lectures in 1899 which were published later in book form under the title "The Induction Motor,"—a short treatise on its theory and design. Translations of this book appeared in French, German, and, in sections, in Japanese.

In 1897 he developed the theory of the regulation of alternators under inductive loads and urged its adoption for purposes of standardization. This is now generally adopted as first proposed by him, though sometimes known under the name of the "Potier" method; a paper before the Institute described the method, with recommendations for standardization. Among other contributions are his Institute papers on the mechanical forces in dynamos caused by magnetic attraction, elementary theory of surges on long lines, the testing of alternators by splitting the field circuit, the proposal, in 1907, to wind electric generators for 22,000 volts or more, and the demonstration of the feasibility of this voltage on 100-kw. generators. In 1902 Mr. Behrend introduced the radial-slot cylindrical turbo rotor type with chrome nickel end rings which is now generally used by all manufacturers of turbo generators. The Bullock Company, jointly with Hoovens, Owen & Rentschler, exhibited a 1000-kw. unit of this type at the World's Fair in St. Louis, in 1904. The unit received a grand prize and Mr. Behrend a gold medal. The largest power unit of the exposition, a 3500-kw. generator driven by an Allis Chalmers engine, was also designed by Mr. Behrend and it secured for itself the name of the "Old Reliable," as it was always functioning when other units were out of commission.

Between 1900 and 1908 Mr. Behrend designed the electric generating units for the Kern River Power Company, the Pacific Electric Company, the Denver Gas & Electric Company, a large group of units for Niagara Falls, the receiving plant of frequency changing units at Montreal, linking the Shawinigan Water & Power Company with the power plants at Montreal, the steam turbine units of the Brooklyn Edison Company and Brooklyn Rapid Transit Company, at that time the largest and fastest of their type. The large gas engine driven units of the Carnegie Steel Company, of the Illinois Steel Company, and of the Indiana Stee Company at Gary, Indiana, were designed by him, representing of the pioneer installations of the world. All necessary calculations for the conditions of parallel operation were carried out by Mr. Behrend, leading to the adoption of very light flywheels of about one-half the moment of inertia demanded by the engine builders.

In 1909 Mr. Behrend introduced the radial slot rotor into the Westinghouse Company and he developed the plate rotor construction now adopted by the Westinghouse Company for its largest sizes of turbo rotors. It was a revolutionary type devised for the purpose of overcoming the defects of large forgings and castings.

Devoted to engineering education in 1901 he started the first engineering training classes at Cincinnati, under Mr. A. G. Wessling. Among his well-known associates have been A. B. Field, who did his work on eddy currents in large slot-wound conductors in Mr. Behrend's office; C. J. Fechheimer, now research engineer for the Westinghouse Company; Messrs R. B. Williamson, Bradley T. McCormick, C. W. Johnson, Alexander Miller Gray were all trained in his office; Mr. F. D. Newbury was his assistant in Pittsburgh.

Mr. Behrend has taken out over eighty patents, mostly assigned to the Allis-Chalmers and Westinghouse Companies. He served on many committees, among them the Standards Committee, the U. S. National Committee, of the International Electrotechnical Commission, the Library Board, the Edison Medal Committee, and others. He was Chairman of the Committee on Professional Conduct, and the Electrical Machinery Committee. He was the first Chairman of the first Institute Section at Cincinnati, and he served five years as a Manager and Vice-President of the Institute.

In 1912 he received the John Scott Medal for improvements on high-speed electric generators. He is a member of the A. S. M. E., the A. S. C. E., and the Franklin Institute; a Fellow of the American Physical Society, the American Association for the Advancement of Science, the American Academy of Arts and Sciences, and of the A. I. E. E.

Abridgment of

Operating Experience with the Low-Voltage A-C. Network in Cincinnati

BY F. E. PINCKARD[1]
Associate, A. I. E. E.

Synopsis.—This paper describes briefly the operating experience arising from the installation of a four-wire 120/208-volt network with combined light and power mains. The most interesting problems of operation are outlined with their subsequent solutions. Fifteen months' network operation indicates that with care in layout and selection of equipment, important operating problems would be negligible.

* * * * *

Introduction

When the a-c. network system was inaugurated in Cincinnati, very few published data were available concerning actual network operating experience. Naturally, numerous problems arose concerned with the design and operation of equipment and the application of the network system to various types of customers' equipment. The problems have been treated with varying degrees of success, and this paper will attempt to present the most interesting of them.

The a-c. network here was designed to ultimately replace the existing three-wire d-c. Edison network in the one sq. mi. of congested business district having a peak demand of 24,000 kw. The ultimate layout provides for eight 13,200-volt feeders of 40,000-kv-a. total capacity with transformer vaults at each intersection and between intersections, as the load warrants. Ten per cent impedance transformer banks of 300- and 450-kv-a. capacity with 400,000 cir. mil secondary combined light and power mains connected four-wire, 208 volts, star, were made standard. A line diagram of the system is shown in Fig. 1.

Network Equipment Problems

With the slight amount of load served by the first network installations, it was natural that the first problems to be encountered were concerned with the network equipment, and particularly with the automatic network circuit breakers. It should be mentioned here that a number of the problems encountered were the results of the extremely small load on the network at the start, and are of importance not so much from the standpoint of service as from the experience gained in the operation of the equipment under this condition.

The first problem arose in one new building where unit multi-voltage type elevators were installed, and where the initial lighting load was small. It was found that network breakers would open due to power reversals. Investigation revealed that elevators using regenerative breaking may feed energy back into the network to the extent of one-third or more of their normal demand. This feedback was sufficient to trip the network breakers which were set for a reversal of approximately five amperes, which is less than the energizing current of the transformer. To correct this condition, heavier magnets were installed on the relays with some success, and later, the current required for tripping was increased to a value just below the magnetizing current of the transformer, thus eliminating most of the trouble occurring during the light-load periods. The gradual increase in the light load served to absorb these reversals.

After solution of the above problem, breaker pumping

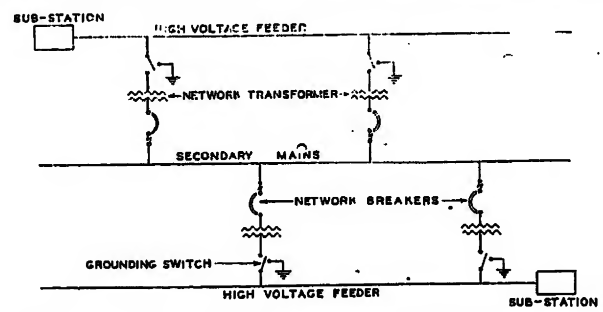

Fig. 1—Single Line Diagram Showing Schematic Arrangement of Low-Voltage Network

was still noted. Investigation revealed that this pumping was due to a slight phase-angle difference between the two primary feeders, which originated at different substations. The single-phase breaker relay was designed to prevent this, but on checking this relay, it was found that the potential elements were reversed. Correction of connections eliminated pumping, but due to light loads, a number of the breakers on one feeder now remained open a considerable part of the time.

When loads of even moderate size were thrown on and off near one of these breakers, severe voltage variations due to the breaker opening and closing occurred. Under these conditions, satisfactory service was impossible; so one feeder was extended to a generating station, thereby reducing the phase-angle difference from two deg. to zero thus eliminating the trouble.

1. Electric Distribution Dept., The Union Gas and Electric Co., Cincinnati, Ohio.

Presented at the Regional Meeting of the Middle Eastern District of the A. I. E. E., Cincinnati, Ohio, March 20-22, 1929. Complete copies upon request.

The large number of breaker operations caused by the power reversals, phase-angle difference and load variations directed attention to the mechanical features of the breakers themselves. Failures of breaker trips and closing solenoids were frequent, and complete inspection as often as twice weekly was necessary to insure satisfactory operation. These failures brought breaker design and construction under serious consideration, particularly with respect to life and accessibility for repair.

The failures could be divided into two classes,—failure to trip due to faulty trip mechanism or poor adjustment, and the burning out of closing coils on solenoid-operated breakers due principally to the tendency of the auxiliary contactor to weld closed, leaving the closing coil energized after the breaker had closed.

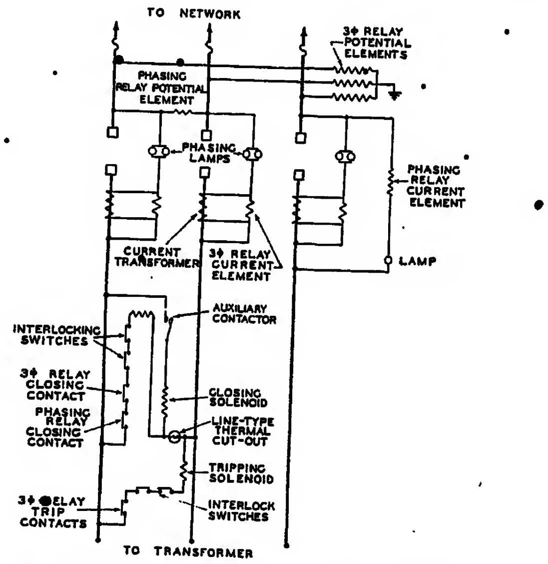

FIG. 4—SIMPLIFIED DIAGRAM OF SOLENOID-OPERATED NETWORK BREAKER

The failure to trip was solved by replacing the old trip mechanism with a new type developed by the manufacturers. The protection of the closing coils was obtained by the use of a link type thermal cut-out arranged so as to protect both the main and auxiliary solenoids as shown in Fig. 4.

Since it was deemed undersirable to jeopardize the tripping function in any way, the idea of fuse protection in the trip circuit was abandoned. The inaccessibility of the submersible breaker for repair or maintenance resulted in the division of the supporting panel into three parts, the upper and lower parts supporting the breaker terminals, and the middle part supporting the operating mechanism. This middle part was designed to permit easy removal from the case for repair.

To check the operation of the trip mechanism, each primary feeder was opened daily during light-load periods. This probably served as well to keep the mechanism in a flexible condition.

Improved operation was obtained by requiring more rigid laboratory tests before placing the breakers in service. These tests are made to reveal any mechanical or electrical defects due to manufacture or damage in shipment, and also to provide inspection and adjustment of all electrical and mechanical parts, including closing and tripping features, contact pressure, and three-phase and single-phase relay operations.

Routine tests are maintained after the breakers are put into service. These tests include checks on the tripping solenoid and closing mechanism, air-pressure tests to assure tightness of the submersible cases, and voltage-drop tests across breaker contacts to indicate faulty contacts or breaker overload. No attempt is made to test the relays in service but each relay is returned to the laboratory at least every three months for a comprehensive test.

One function of the network which is of primary interest is its ability to burn clear any secondary faults. Since the secondary mains installed were all new cable, secondary faults were cleared without noticeable effect on the system. One of these faults occurred in a splice,—a very severe test of the ability to clear, but the action was entirely successful even though the time of clearing was prolonged.

Only one high-voltage fault occurred,—the failure of a transformer bushing. The oil circuit breaker opened on current to ground and all breakers cleared successfully. The difficulties experienced in locating this fault are of interest.

The usual method of locating high-voltage cable faults has been to break down the insulation resistance at the fault, circulate about 30 amperes, d-c., through the conductor and back through the lead sheath; then to locate the fault by means of a multi-voltmeter, used

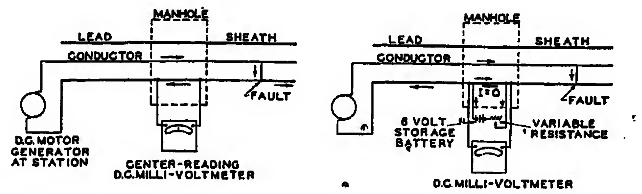

FIG. 5—(a) USUAL METHOD OF LOCATION OF HIGH-VOLTAGE CABLE FAULTS

(b) METHOD OF LOCATION OF HIGH-VOLTAGE NETWORK FEEDER FAULTS

to indicate the direction of flow in the sheath. Due, however, to the large number of return paths for the sheath current, (since the lead sheath is grounded to the transformer case and the transformer case is in turn grounded to the neutral), an attempt to locate the fault by this method proved unsuccessful and conflicting and misleading results were obtained.

A second method which is quite satisfactory for locating primary faults has since been devised. Direct current is circulated through the fault as before, and the sheath current is then neutralized in the various manholes by current supplied from a storage battery. The

direction of the fault is shown by the effect of the fault current in the conductor on a compass needle.

Diagrams of these two methods are shown in Fig. 5.

Regulation

Regulators were not installed on the primary feeders until some time after the network was in service. Two single-phase regulators, connected open delta and mechanically interconnected, were installed on each feeder. A slight difference in secondary phase voltage, noticed soon after they were in service, was remedied by

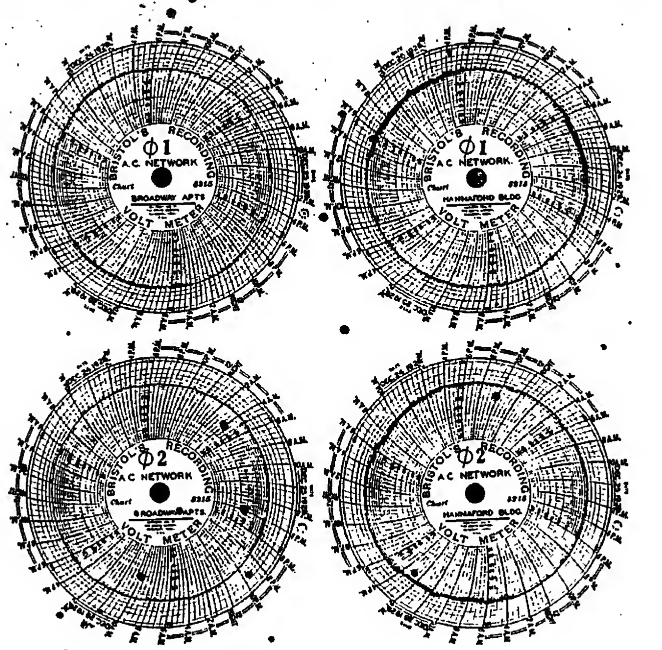

Fig. 6—Voltage Charts from Representative Network Services

adjustment of the mechanical connection between the two regulators of one feeder. Because of the possibility of causing pumping, and also because of the various types of load connected, no attempt was made to regulate to any one point on the secondary, but rather to regulate to imaginary points approximately half-way through the secondary of each transformer, using the same compensator setting on each feeder.

When the regulators were put in service, it was found that the kv-a. load of one was at times double that of the other, whereas the division had taken place even before using the regulators. No appreciable phase-angle difference existed, and changes in compensation failed to improve matters. It was finally discovered that one set of regulators was not operating properly due to an improper internal connection. After this fault was corrected, compensation was determined by trial, and to date, the operation has been satisfactory.

It may be of interest to know that there is no mechanical nor electrical connection whatsoever between the two sets of regulators, one set operating on a feeder from a generating station, and the other on a feeder from a substation fed from this generating station and supplying both d-c. and a-c. loads.

Four general types of load are supplied by the network: manufacturing, hotel, office building, and theater. The voltage charts shown in Fig. 6 are typical charts and indicate that regulation on the above basis gives uniform voltage throughout the system despite the various types of load served.

No network disturbances have occurred since the regulators have been in operation; hence no data are available as to their behavior under such conditions.

To prevent the starting currents drawn by large motors from lowering the lighting circuit voltage excessively, reactors were placed in the secondary bus as shown in Fig. 7. These reactors, of course, cannot be used for regulation purposes with a single transformer. Where a single transformer supplied both light and power, disturbance was prevented by reconnection of the motor starters. This required a longer starting time for the motors, but there were no complaints on this account.

Regulations are contemplated requiring the use of increment starters on motors connected to the network where the motor is large enough to cause lighting flicker. The use of this type of starter on a 200-hp. motor connected to compressors produces no noticeable change in the lighting voltage.

Operating Problems on Consumer's Equipment

Since 120 volts for lighting has been standard in Cincinnati for a number of years, especially since it offers more nearly the rated three-phase voltage for motors, there was no reason for deviating from this for the network.

It is recognized that a motor operating with 75 per

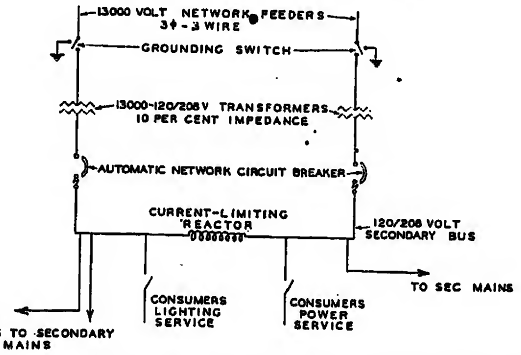

Fig. 7—Line Diagram of Double Transformer Vault Installation

cent or less of rated load will give just as satisfactory service when operated on 208 volts as when operated on 220 volts, and as had been expected, the greater part of the motor installations to be changed to the network service was found to fall in this class.

Auto-transformers have been installed for heating units rated at 220-240 volts; also in a few cases where contracts made with customers prior to the installation of the network contained clauses requiring 240 volts, three-phase service for power. It is no longer the practise, however, to install them for new loads.

Design and Construction Details

Figs. 8 and 9 show the construction details of sidewalk vaults which are typical of a majority of the

installations here. In the case of the double vault, the breaker compartment is located within the building wall, while the single vault is located entirely within the sidewalk. The transformers are of the type ordinarily used for low-voltage networks with grounding switch on the high side having line open, ground, and

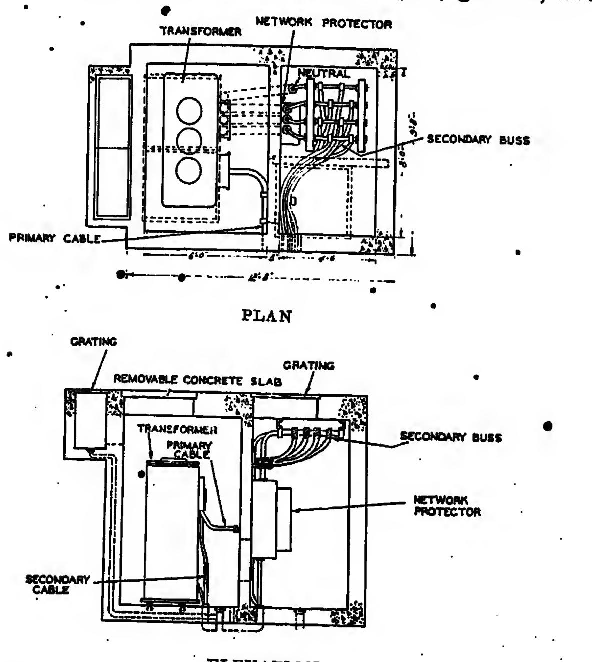

Fig. 8—Standard Sidewalk Vault for Installation of One Three-Phase Transformer

closed positions. A holding coil energized by the secondary of the transformer prevents the operation of the switch when the transformer is energized. Both open and submersible type network breakers are used, the former when installed in buildings, the latter in sidewalks. In all cases transformers are of the submersible type.

Considerable reduction in size and weight of transformers has been effected by installing the grounding switch in the high-voltage pothead. This also permits such work as changing the oil to be done by throwing the grounding switch to the open position instead of opening the primary feeder as was necessary with the old type transformers.

The simplicity of installation makes the use of three-phase transformers more desirable than three single-phase transformers.

Experiences indicate that sidewalk vaults are preferable to those in buildings from the standpoints of installation, removal, and operation of equipment.

The necessity of phasing out from substations is eliminated by marking each phase in every splice. This saves much time in cutting in new banks and replacing faulty lengths of cable.

Equipment Characteristics

The shunt-trip type of network breaker was selected in preferance to the holding coil type because of the possibility that voltage disturbances of a general nature might cause undue outages, since the holding coils will not stay in below 35 per cent normal voltage. Later experience proved the wisdom of this selection when several undesirable outages were prevented by the use of the shunt-trip type.

In selecting the amount of transformer impedance necessary, it was felt that it should be as high as was possible commensurate with satisfactory regulation. The use of high impedance reduces the size of the secondary mains allowable due to limiting the fault current, but this difficulty can be overcome by installing more than one set of smaller mains. This is usually the most economical method of extending the secondary system. The 10 per cent impedance transformers as used in Cincinnati have proved very satisfactory, both from the standpoint of regulation and load distribution between transformers.

Conclusion

As has been stated, the difficulties encountered were not of major importance and investigation as to their causes showed that the remedies to be applied were after all comparatively simple. They did serve, however, to bring out many of the main features to be considered

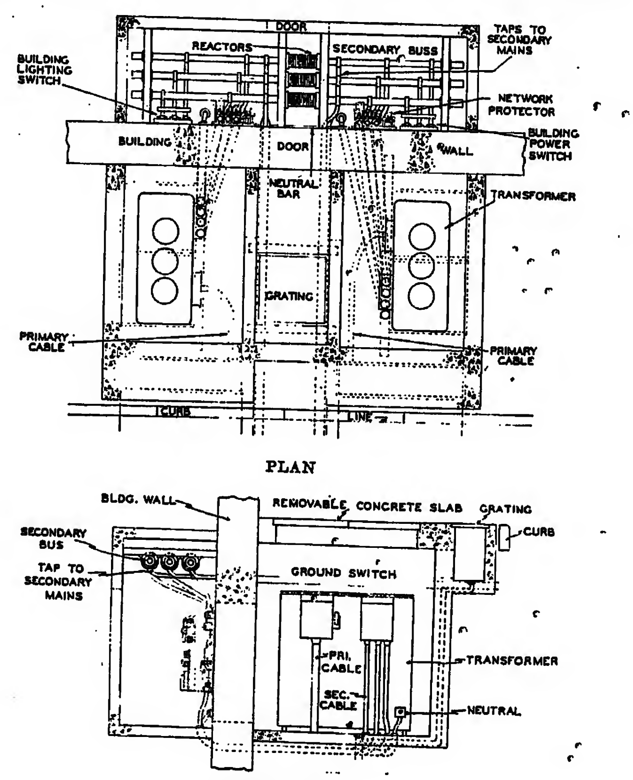

Fig. 9—Standard Sidewalk Vault for Installation of Two Three-Phase Transformers

in the layout of the system and in the selection and maintenance of the equipment.

Here, it has been the aim to furnish a-c. service to the downtown district comparable in reliability with that of the Edison System. Since there have been no interruptions in service other than local ones during the fifteen months that the low-voltage network has been in operation, it is felt that this has been accomplished.

Abridgment of

Electrical Equipment of Bar Plate and Hot Strip Mills

BY J. B. INK[1]

Member, A. I. E. E.

Synopsis.—The paper describes the electrical features of a continuous bar plate and hot strip mill recently placed in service at Middletown, Ohio, including information regarding the general layout of the plant, the electrical circuits, rolling mills, the various motor drives, control arrangements, the motor-generator sets for supplying d-c. motors, and the safety devices. It also gives test data on the power consumption.

* * * * *

THE purpose of this paper is to describe the electrical features of the continuous bar plate and hot strip mill recently placed in service by The American Rolling Mill Company at Middletown, Ohio.

The new mill produces ingot iron and various grades of steel strip in gages down to 0.093 in., and widths up to 48 in. Also plates ¼-in. thick and 60-in. wide in 75-ft. lengths. These products are rolled from 6-in. thick slabs, 39-in. long and of the width required in the finished product. For ease in handling and storing, the strip steel is coiled on leaving the last stand of the hot strip mill.

The mill consists of 11 stands. The first seven constitute the "bar mill" and normally reduce the sheet to about 3/8-in. thickness. The last four stands are the "hot strip mill." Between stands No. 7 and No. 8 is a runout table, transfer and bar piler for taking off sheet bar or other heavy gage product.

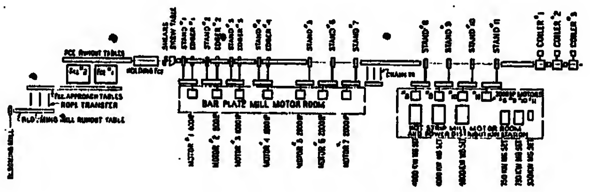

FIG. 1—GENERAL ARRANGEMENT OF BAR PLATE AND HOT STRIP MILLS

The independent stands No. 1 to No. 4 are each driven by a wound secondary induction motor and are equipped with fly-wheels. The motor horsepower varies from one quarter to one half the total rolling hp., the balance of the rolling energy being taken from the fly-wheel. The output of the motor is limited by automatic liquid slip regulators which introduce resistance in motor secondary as the motor primary current increases and so permits the fly-wheel to give up stored energy.

The characteristics of the first four stands are as follows:

Motor	Hp.	Speed synch.	Fly-wheel hp. sec.	Gear ratio	Mill rev. per min.	Roll dia. inches	Roll ft./min.
1	800	514	30,000	35:1	14.42	32	121
2	800	514	30,000	35:1	14.42	32	121
3	1000	600	40,000	29:1	20.18	32	169
4	1200	720	40,000	29:1	24.3	32	203.5

Motor primary is connected to main bus by Westinghouse type OE6 oil circuit breaker. For plugging there is provided a Westinghouse Type B2 breaker which connects the motor to reverse bus. The reverse bus is connected to main bus by an OE6 breaker. The forward breaker and reverse bus breaker are automatic on overload and under-voltage. Thus one automatic breaker gives under-voltage and overload reverse protection to the four motors.

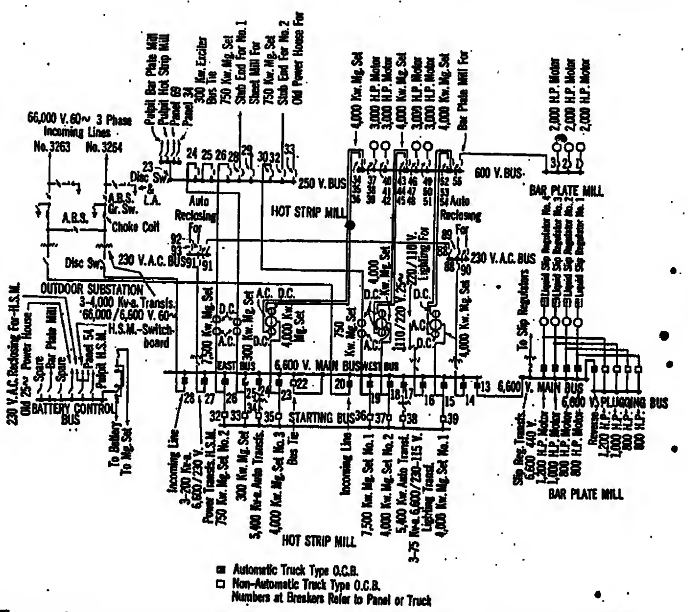

FIG. 2—DIAGRAM OF ELECTRICAL CIRCUITS IN ROLLING MILL

Oil circuit breakers are truck type having all hot parts enclosed. Forward and reverse breakers are interlocked electrically and mechanically to prevent simultaneous closing.

1. Dwight P. Robinson & Company, Inc., Middletown, Ohio.

Presented at the Regional Meeting of the Middle Eastern District of the A. I. E. E., Cincinnati, Ohio, March 20-22, 1929. Complete copies upon request.

The inter-dependent stands No. 5 to No. 11 inclusive are driven by 600-volt d-c. adjustable speed motors. Due to the necessity for close speed regulation and the fact that the piece is in the stand a considerable length of time fly-wheels are impractical on these stands.

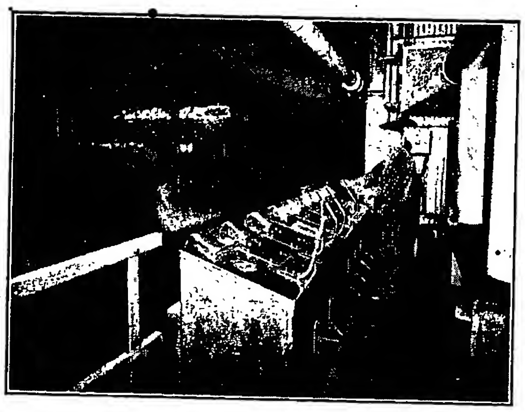

FIG. 3—CONTROL PULPIT, HOT STRIP MILL

This pulpit controls four 3000-hp. adjustable speed d-c. motors and approach and run-out tables for this mill.

The motors, therefore, must provide maximum rolling torque.

Characteristics of stands No. 5 to No. 11 are as follows:

All 4-high 56-in., working rolls 18-in. diameter, backing up rolls 36-in. diameter, roller bearings.

Motor	Hp.	Speed	Gear ratio	Mill r. p. m.	Roll ft./min.
5	2000	300–500	8.1:1	37.1/ 61.70	174.7–291.0
6	2000	300–500	6.00:1	50 / 83.3	235.4–392.0
7	2000	300–500	5.32:1	56.4/ 94.1	266.0–443.0
8	3000	180–360	3.02:1	59.6/119.2	280.5–561.0
9	3000	180–360	2.26:1	79.7/159.4	375 –750.0
10	3000	180–360	1.87:1	96.3/192.6	454 –908.0
11	3000	180–360	1.72:1	104.8/209.6	494 –988.0

The seven d-c. 600-volt motors are heavy duty type with low pedestal bearings and fabricated structural steel bases. The 3000-hp. motors being of very low speed require forced air ventilation. Motors are equipped with bearing thermostatic relays, overspeed devices, and heaters to prevent sweating during shut-down. To each shaft is geared a speed-indicating magneto. These motors are constant horsepower, speed adjustable by field control. Motors are compounded by use of series exciters. The series exciters consist of generators driven by 5-hp. induction motor. The generator field is excited by three quarter turn of the main motor armature circuit, so that the voltage generated is proportional to the input to the main motor. The generator circuit supplies a series field winding similar to the shunt winding on the main motors. Shunt-field excitation is at 250 volts.

Compounding is adjusted to different motor speeds by a rheostat in the series exciter circuit. This rheostat being on the same shaft as the main shunt-field rheostat is automatically adjusted with main shunt field.

The d-c. motors are controlled entirely from the operator's pulpit, except that emergency stop-control switches are provided in motor rooms. They are started from a 600-volt d-c. bus through series resistance and contactors using current limit accelerating relays. Dynamic breaking is used in stopping mills.

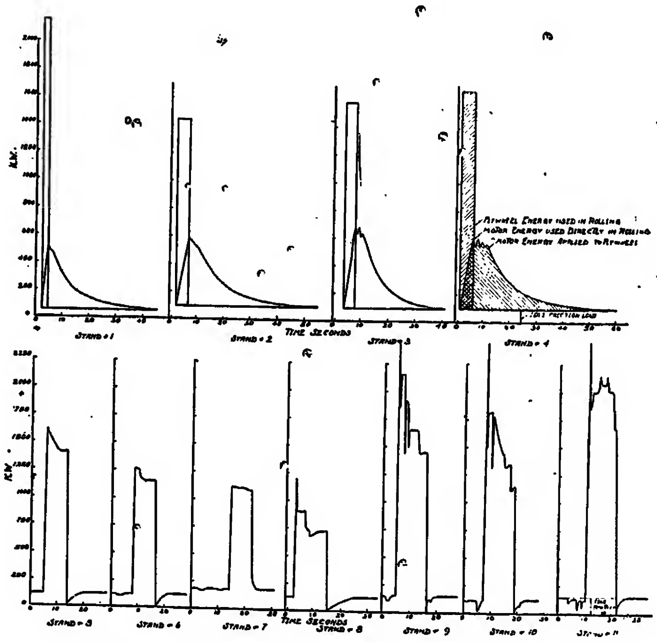

FIG. 4—INPUT TO MILL MOTORS

Motors are protected from overload, low-voltage, field failure, and over speed. Each motor control panel is connected to the main bus through disconnects so that panels may be isolated for repair without killing the main bus.

With a few exceptions the mill auxiliaries are motor

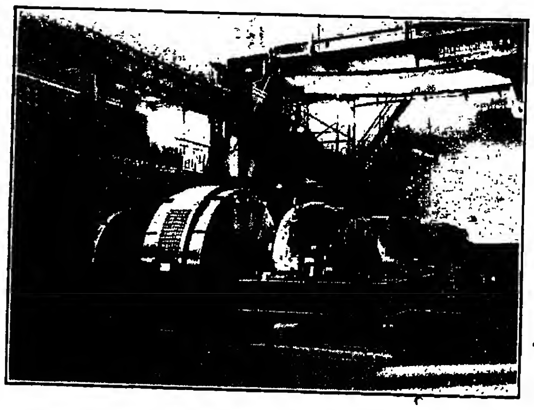

FIG. 5—4000-KW. 600-VOLT D-C. 6600-VOLT A-C. MOTOR GENERATORS

These machines supply d-c. power for the d-c. mill motors

operated, 220-volt squirrel-cage induction type motors with magnetic cross-line starters being used for all constant speed continuous duty applications, such as fans, pumps, and chain tables between mills. These motors are in sizes from 2 to 75 hp. They are standard sleeve bearing motors with drip proof covers. The

cross-line starters provide low-voltage protection and have thermal overload relays.

For intermittent duty on loads having high starting torque and requiring quick acceleration, 250-volt d-c. mill type series or compound motors are used. This includes all cranes, transfer tables, roller tables, except hot strip run-out table; furnace pushers, pinch rolls,

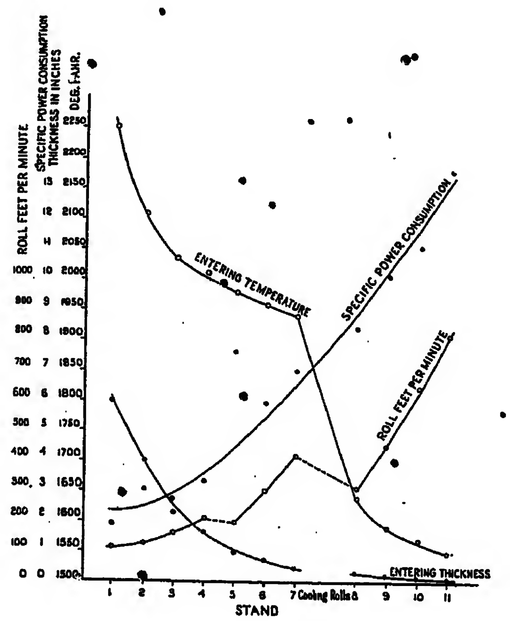

FIG. 6—RELATIVE VALUES AT EACH STAND OF ROLL SPEED, SPECIFIC POWER CONSUMPTION, THICKNESS OF METAL AND ENTERING TEMPERATURE

Specific power consumption equals hp.-sec. per cu. in. of metal displaced

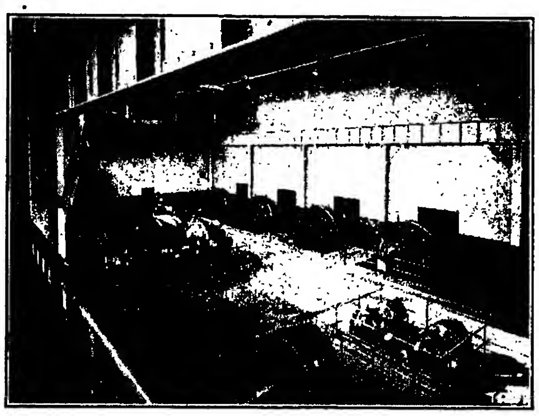

FIG. 7—HOT STRIP MILL MOTOR ROOM

This room also houses the motor-generator sets and main control switchboard

and screw-downs. The controls for these motors are all of the magnetic definite time limit acceleration type. Excepting for cranes, the control panels are arranged in groups in dust-tight brick rooms.

Power for operating the new mill is purchased from the local power company at 66,000 volts. Service is over about four miles of double circuit steel tower line from the power company's substation at Trenton to a step-down transformer station at Middletown, built and owned by The American Rolling Mill Company.

Automatic oil circuit breakers are provided in the line at the 66,000-volt substation at Trenton and at the 6600-volt bus at the mill. Normally a 66,000-volts line transformer bank and 6600-volt line form an independent unit. No switching is done at 66,000 volts at the mill. However, disconnects are provided for isolating transformers and lightning arresters, and provision is made for adding oil switches when required.

The main bus for distribution of power at 6600 volts is in two sections. Each section is supplied by one of the transmission units. Feeders are so arranged on the bus sections that one section may be taken out of service for additions or repairs without a complete shut down of the mill. The two bus sections are tied together by a non-automatic oil circuit breaker.

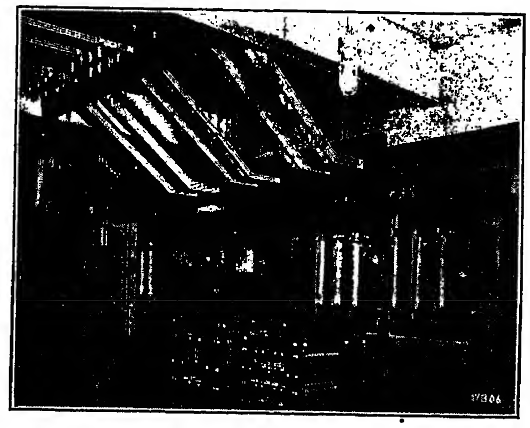

FIG. 8—600-VOLT D-C. ALUMINUM BUS STRUCTURE

In basement of hot strip mill. The supports are ebonized asbestos in welded steel frames

All 6600-volt circuits are protected by induction type overload relays. The two incoming lines are equipped with balanced reverse power and overload relays. These lines are similarly equipped at the power company's substation and, in addition, have ground relays. By means of this system, either transmission line is immediately switched off at both ends if it develops any trouble other than a single-phase ground on the 66,000-volt line. In the latter case, the circuit is opened automatically at the power company's substation, and an alarm is sounded at the mill to notify the operator to open his switch by hand.

The 600-volt direct current for main mill motors is supplied by three 4000-kw., three-unit synchronous motor-driven motor-generator sets. The 250-volt direct current for auxiliary motor circuits is supplied by two 750-kw. motor-generators sets, and 250-volt excitation by a 300-kw. motor-generator set. The excitation may also be supplied from the 750-kw. motor-generator sets.

Each 4000-kw. 600-volt motor-generator set consists of two 2000-kw. 600-volt generators rigidly coupled to a 5800-hp., 85 per cent power factor, 6600-volt, 60-cycle, 14-pole synchronous motor. One of these units is shown in Fig. 9.

The field of each 2000-kw. generator is arranged for 125-volt excitation. The fields of the two generators are connected in series and excited from a 250-volt constant voltage excitation bus. These generators have straight differential and crossed cumulative series fields, assuring equal division of the load between the two generators of the set. The three sets are operated in parallel by the use of double-pole equalizers between sets.

The two 750-kw. 250-volt generators are driven by 1080-hp., 900-rev., per min., 80 per cent power-factor synchronous motors, and the 300-kw. 250-volt exciter

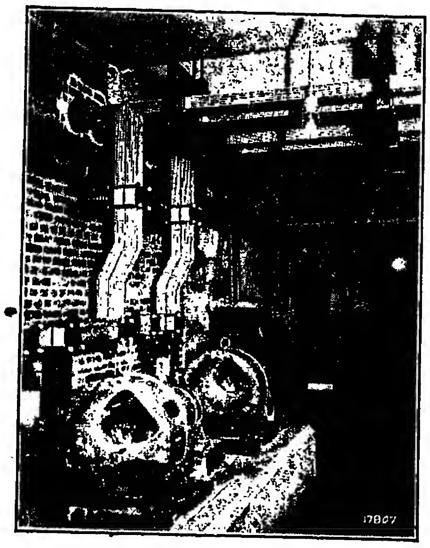

FIG. 9—SERIES EXCITER SET AND 600-VOLT D-C. ALUMINUM BUS STRUCTURE

by 432-hp. 1200-rev. per min. 80 per cent power-factor 6600-volt synchronous motor.

The 220-volt., three-phase power for auxiliary motors is from two automatic substations located near load centers. Each consists of a bank of three 200-kv-a. 6600/220-volt transformers and two automatic reclosing 1200-ampere, 220-volt, three-phase feeder panels. A tie connection is run between substations to carry part of substation load in the event of transformer failure.

The 250-volt d-c. system is supplied through automatic reclosing feeders from the 250-volt bus in the power distribution station. This bus is connected by tie lines to two other 250-volt d-c. generating stations in the plant.

Lighting is provided by an overhead system of lights suspended from a messenger wire. The messenger wire suspension prevents lamp breakage due to vibration of buildings, and permits arranging units for uniform light distribution.

Illumination values (foot-candles) are as follows:

Bar plate mill	3.5
Hot strip mill	3.5
Warehouses	3.
Switchboard and motor rooms	6

Provision is made for emergency lighting so that in case of failure of the 60-cycle service a system of emergency lights is automatically thrown on to storage battery service until the station operator can transfer the main lighting to a bank of transformers connected to the plant 25-cycle system.

Branch circuits are protected by circuit breakers with direct-acting time limit feature.

Lighting fixtures are individually fused and are arranged with a disconnecting device for ease of replacement and maintenance.

Both motor rooms are ventilated with filtered air. In the bar mill motor room the air is delivered by a 57,000-cu. ft. per min., 1¼-in. single-phase fan to the basement and thence to the pits under the motors. The air is filtered by two 30,000-cu. ft. per min., rated, rotary type air filters. The system is so arranged that all or part of the air may be recirculated and also may be heated by passing through a group of unit type steam heaters.

The hot strip motor room is ventilated by two 70,000-cu. ft. per min. 1½ in. single-phase fans which take care of the heat losses from motor generators, and two 65,000-cu. ft. per min., 3-in. single-phase fans which supply the forced air ventilation for the mill motors in this room. The air is cleaned by six 50,000-cu. ft. per min. rotary type air filters and may be recirculated and heated when necessary.

The grounding system is complete in all parts of the system.

Insulating mats are provided in front and rear of all switchboards.

A safety switch is installed in the leads of all motors, at the motors, so that when repairs or adjustments are made to the machines driven by such motors the switch may be opened and so make it impossible for others to start motor.

The electrical work in this mill was designed and constructed by The Dwight P. Robinson & Company, Inc., under the direction of The American Rolling Mill Company, which is the owners of the patents involving many of the mechanical features, as well as the rolling process in the above description.

More than 70 members of the women's division of the Electric Association of Chicago have registered for a course in electrical home making which is now being conducted. The course includes lectures and demonstrations of the use of all the usual household devices operated by electricity, including lighting, heating, and motor-operated appliances.

Abridgment of

Effect of Transient Voltages on Power Transformer Design

BY K. K. PALUEFF*

Associate, A. I. E. E.

Synopsis.—*When an ordinary transformer is subject to transient voltage excitation, local concentration of voltage takes place in which the capacitance charging current of the coils to ground is supplied through the winding. This is because the ratio of inductance and capacitance of the various parts throughout the winding is not constant. Calculations and tests of voltage distribution in the winding, caused by the impact of (a) damped high-frequency oscillations, and (b) unidirectional traveling waves, are given. In order to make the analysis clearer, the transformer winding is considered as a network of inductances and capacitances, and this term "network" is used throughout the paper. Certain simplified and typical networks are considered.*

Transformers having one terminal grounded, such as are used in three-phase star connection, particularly in high-voltage systems, are frequently built with the insulation graded to other windings and ground, in the order of the normal frequency voltage stress. The danger of such a practise is shown in power transformers which are subject to transient overvoltage, since voltage oscillation in the winding may raise the voltage to ground at intermediate points above the terminal voltage, unless the design of the winding eliminates oscillation.

The theoretical and experimental data given show that the distribution and magnitude of voltage stresses existing during recognized standard insulation tests are essentially different from stresses created by transient voltages. This permits the construction of transformers that would satisfactorily pass standard insulation tests but at the same time would not be suitable for average service.

A new type of a transformer called "non-resonating," for use on grounded neutral systems, is described.

In transformers of this type, voltages of all frequencies distribute uniformly along the windings, as the possibility of internal voltage resonance is eliminated by a proper balance of distributed capacitance and inductance of the winding.

This is accomplished principally by means of conducting surfaces (shields) placed outside of the winding and connected to its line terminal.

The action of the shields is similar to that of the shielding ring on an insulator string. It neutralizes the effect of the capacitance current from the inside surface of the winding to ground, by supplying to every point of the winding a "charging" current equal to the "discharging" current of that point to ground. In some cases, the application of the shield reduces the local stresses to one-eightieth.

Up to the present time, the total capacity of this new type of transformer exceeds half a million kv-a.

If the problem of designing the transformer insulation were limited to the requirements of normal frequency dielectric stress, it would be relatively simple.

It is not, however, the normal voltage stresses which, in high-voltage transformers, require the most careful consideration to predetermine the amount, kind, and arrangement of the insulation, but the transient stresses set up by abnormal conditions on the circuit.

The necessity for extra insulation, above that required to meet the A. I. E. E. test (or any other recognized standard rules) is due to two facts:

1. Transformers, even of high voltages, are subject to transient voltages many times the normal circuit voltage to ground. Records show from 10 to 15 times normal voltage to ground even on 220-kv. systems.

2. Most transient voltages are high-frequency oscillations, or are traveling waves lasting a number of microseconds, and the ordinary transformer does not permit these voltages to be uniformly distributed throughout the winding. This is because the transformer winding is not a pure inductance, but also contains distributed capacitance.

To determine the effect of the above considerations on the transformer design two alternative designs of 20,000-kv-a., 220,000-volt transformer were prepared Both alternatives were to satisfy identical operating characteristics as efficiency, reactance, potential test, etc.

The first design was made in accordance with the A. I. E. E. Standards, as well as transient voltage requirements developed by the years of experience and incorporated into practise for at least ten years.

The second design was made in accordance with A. I. E. E. Standards only.

The comparison revealed that first transformer cost 40 per cent more than the second and has 75 per cent more of active material than the second.

It is important to note that the second transformer would withstand successfully not only the tests called for by A. I. E. E. Standards but also all the tests called for by any other recognized standard rules including those which specify so called "surge or impulse test." This is because such tests impose on transformers transient voltage of an amplitude negligible in comparison with those experienced in actual service.

With the assistance of two previous papers,[1,2] and much additional study and experiments, a new type of transformer has been developed, for operation with solidly grounded neutral, which is believed to be better adapted to resist stresses caused by voltage transients than any type used heretofore.

*Research Engineer, Transformer Engg. Dept., General Electric Company, Pittsfield, Mass.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Jan. 28-Feb. 1, 1929. Complete copies upon request.

1. A. I. E. E. TRANS., Vol. XXXVIII, p. 577.
2. A. I. E. E. TRANS., Vol. XLI, p. 149.

Equivalent Networks

Most engineers, who deal with electrical phenomena of commercial frequencies only (25 to 60 cycles), picture to themselves inductance as a spiral wire, and capacitance as two parallel plates, and therefore are not apt to recognize these characteristics when they are disguised in different geometric forms. Furthermore, again due to everyday experience with low frequencies, they are accustomed to think of some apparatus (such as transformers and choke coils) as pure inductances, and of others as pure capacitances (parallel plates, synchronous condensers), or as resistances. To discard

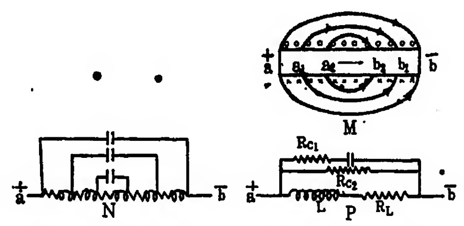

Fig. 1—Equivalent Circuit of a Simple Conductor

these faulty notions is the first step toward the understanding of transient phenomena.

A straight piece of conductor, no matter how small and regardless of its material, is not a pure resistor, but is equivalent to a complicated network of elementary condensers, inductances, and resistances such as shown in Fig. 1.

Ordinary Transformer

Equivalent Network. At operating frequencies, transformers act as inductances in series with some resistances. But, as was shown above, no apparatus or any part thereof can be free of capacitance,—therefore the capacitance must be present in the transformer.

Taking each separate coil (disk or pancake) as an element, a transformer equivalent network becomes as shown in Fig. 3.

The network shown in this figure lacks negative inductance links representing mutual inductance between various parts of the winding. Whenever calculated results of a transformer's behavior are given in this paper, the effect of mutual inductance is properly taken into account.

The Cause of Voltage Resonance in a Transformer. In case the winding is uniform in its construction, the constants of the equivalent circuit will be uniform, and a definite relation between the magnitude of succeeding voltage resonance frequencies can be expected.

The fundamental natural frequency of transformers ranges from about 1000 to 60,000 cycles, and their harmonics of practical importance reach 750,000 cycles.

It so happens that the natural frequency of circuits connected to the transformer in service range between the same limits as do the natural fundamental and harmonic frequencies of transformers.

Referring to network C of Fig. 3 of an ordinary winding, we find that while inductances L, as well as series or internal winding capacitances C_w, are all alike, the capacitances C_s, from the surface of the winding to ground, (the "shunt" capacitances) in spite of their being alike among themselves, make reactances of elements $a\,b$, $b\,c$, $c\,d$ differ from one another, thereby causing voltage resonance conditions.

Should capacitances C_s, therefore, be removed, or their effect on the winding be neutralized in some manner, the reactance of all the elements of network C, (Fig. 3) will become one and the same; and as such a circuit is incapable of voltage resonance, voltage of all frequencies will distribute along it uniformly.

This conclusion is of fundamental importance.

Initial Voltage Distribution with Rectangular Traveling Wave. It was shown above that a transformer has two parallel paths from one terminal to another, one a pure inductance and the other a pure capacitance. This means that at very high frequency the current will follow the capacitance path, and at low frequency, the inductive path.

A sufficiently steep front of a traveling wave corre-

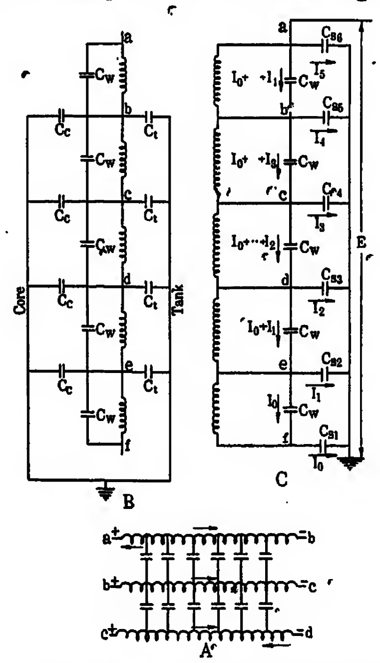

Fig. 3—Transformer Equivalent Network

A. Network of adjacent turns
B. Network of entire winding.
C. Simplified B.

sponds to a quarter of a cycle of a very high frequency, and therefore its current will follow the capacitance path alone. This means that during the rise of terminal voltage from zero to crest of the wave, no current will flow along the conductor, and the transformer will act though every turn is disconnected from the adjacent one; that is, as a pure condenser. This state is called here the initial, or electrostatic. (See Fig. 20).

The condition of voltage concentration at the line end of a string of insulators is well understood. In a similar way, in the transformer it is caused by the presence of the shunt condensers, because the current

of the shunt condenser must flow through the series condenser as shown on Fig. 3. Therefore, starting at the ground end, each succeeding series condenser C_w carries more current than the preceding one. As all series condensers are alike, it is obvious that the magnitude of their voltages will correspond to magnitudes of their currents.

The concentration of voltage will be the greater, the greater the shunt capacitance in comparison with series capacitance.

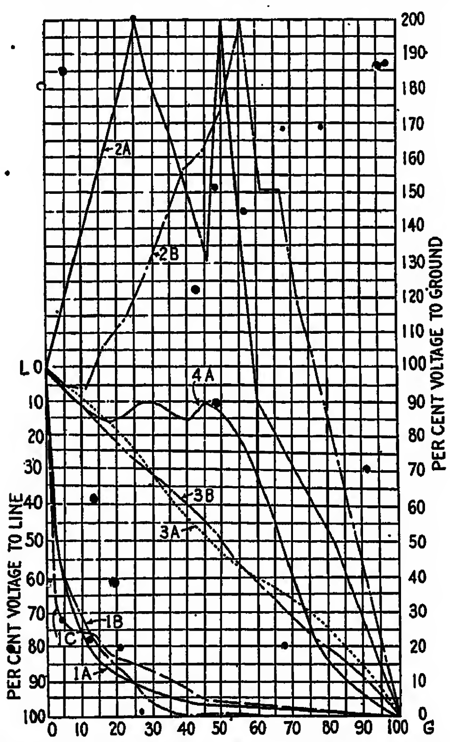

Fig. 20—Voltage Stresses Measured in Transformers Under Test

Transformers tested: (A), core type; (B), core type; (C) shell type.
Non-Shielded
Curves 1A, 1B, 1C: Initial voltage distribution with traveling wave on transformers *A*, *B* and *C* respectively (without entrance bushing). (Dots indicate measured voltages on *C* with entrance bushing).
Curves 2A and 2B: Envelope of voltages in transformers *A* and *B* produced by damped oscillations.
Curve 4A: Envelope of oscillations caused by traveling wave on transformer *A*.

Shielded (Non-resonating)
Curves 3A and 3B represent envelopes of all voltages caused by damped oscillations from 3 to 1000 kc. as well as steep front traveling waves on transformers *A* and *B*, respectively.

b. Voltage Distribution during Oscillation. Assume for the time that the traveling wave is infinitely long and therefore its crest acts on the transformer network (Fig. 3) as d-c. voltage and thus chooses the inductance path for its current. The permanent or "final" voltage distribution will be perfectly uniform and appear as the straight line *L G*, (Fig. 20).

The difference in initial and final states is apparent and will cause a transient state which will consist of a number of sinusoidal oscillations of various frequencies and amplitudes superimposed on one another.

It can be shown that the axis of oscillation is the final state of a given point in the winding, while its amplitude is the sum of the amplitudes of all natural frequencies of the circuit.

Traveling Wave with Slanting Front.

a. Initial Voltage Distribution. From the discussion of initial voltage distribution due to rectangular front an impression may be gained that a very steep front is necessary to create a purely electrostatic field in the winding, and therefore the concentration of voltage at the line end of the winding cannot be experienced in practise where rectangular waves do not exist.

b. Voltage Distribution during Oscillation. Fig. 24 illustrates the effect of the length of the wave-front on voltages created by the oscillation following the initial state.

Curves 1, 2, 3, and 4 show the rise of voltage above ground at the middle of the transformer winding, caused by voltage waves at the transformer terminals as shown by curves 1a, 2a, 3a, and 4a, respectively.

There is practically no difference between the maximums of curves 1 and 4, in spite of the great difference between the exciting waves 1a and 4a. It should be noted that the 4a wave has a front of 30 microseconds.

Wave with Steep Tail.

If a traveling wave with a steep tail, such as would be caused by an insulator flashover, strikes a transformer, severe internal stresses may be set up in the latter if it is of the ordinary design.

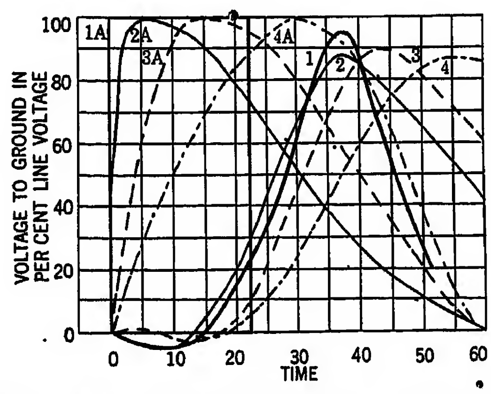

Fig. 24—Effect of Slanted Front on Oscillation of Middle of Winding of Transformer B

1 A, 2 A, 3 A, and 4 A—voltage at transformer terminals
1, 2, 3, and 4—voltage at the middle of winding

Transient Voltages in Practise

Upper Limit of Transient Voltages.

Laboratory experiments, completely substantiated by service records, show that on most of the existing transmission systems transient voltages reach values beyond the dielectric strength of the line insulation. Many lightning waves of crest values equal to 10 times normal line voltage, and a few up to 15 times normal voltage and switching surges up to 8 times normal have been recorded.

5. Conclusions.

The following table shows the order of magnitude of voltage stresses produced between different elements of a transformer winding having one end permanently grounded. Column I gives stresses produced by the standard Induced Voltage Test. Column II gives the dielectric strength necessary to withstand service transients produced in a uniform winding.

In the numerical example, Column III, the minimum values (in kv.) are given for a typical transformer to be operated on a 220-kv. system.

The voltages in Columns I and II are given in terms of effective value E, which is the normal operating line to neutral voltage of the transformer.

	I	II	III
High-voltage line end to low voltage and ground	3.46 E	3.46 E	440 Kv
Any other point between line and ground end p % away from ground end	p E	3.46 E Unless p is less than 10%. Some reduction is permissible for p less than 10%.	
Turn ins. of line coil..	100 to 600 V.	0.63 E	80
Turn ins. near line coil	100 to 600 V.	Gradually reduced from 0.63 E to 0.20 E	
Turn ins. in the main part of the winding..	100 to 600 V.	0.20 E	25
at ground end......	100 to 600 V.	0.35 E	44
Coil to coil at line end..	0.04 E	1.3 E	165
Coil to coil near line end	0.04 E	Gradually reduced from 1.3 E to 0.65 E	
Coil to coil in the main part of the winding.	0.04 E	0.65 E	82
near ground end...	0.04 E	0.88 E	110

The difference between values of the first and the second columns is responsible for the difference in cost and volume of 20,000-kv-a. 220-kv. transformers referred to in the Introduction.

Part IV

Protection Against Transient Voltages

1. Non-Resounding Transformers.

a. Theory. It was shown above that the cause of non-uniform voltage distribution along transformer windings was due to the presence of shunt capacitance (C_s in network 3 of Fig. 3), because, due to this shunt capacitance, damped (or sustained) oscillations of a series of frequencies, applied to the terminals of such a network, cause different parts of it to get in voltage resonance and produce over-voltages shown by the curves (2 A, 2 B of Fig. 20).

In the case of traveling waves, the same shunt capacitances were found to be responsible for internal over-voltages, as the initial and final voltage distributions were different because the charging current of all shunt capacitances were supplied through the series capacitances, causing concentration of voltage at the line end at the time of impact of the wave.

With the effect of shunt capacitances neutralized, there would be no shunt current to be supplied by any series capacitances, and as they are all alike, the initial voltage would be uniform. The final voltage distribution also will be uniform, as all elementary inductances are alike and therefore there will be no transient.

Referring to A of Fig. 25 on the left side of the transformer equivalent network a new system of shunt condensers C_p is shown. This system, however, is not connected to ground as C_s are, but to the line terminal.

It is obvious that values of each capacitance (C_p) can be selected so that with the voltage uniformly distributed throughout the winding, the current

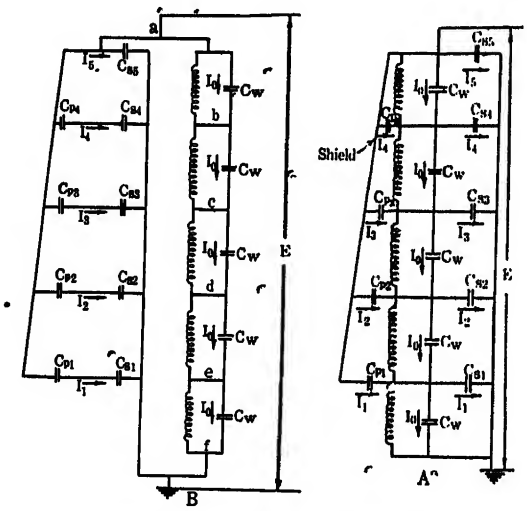

Fig. 25—Equivalent Network of Shielded Transformer

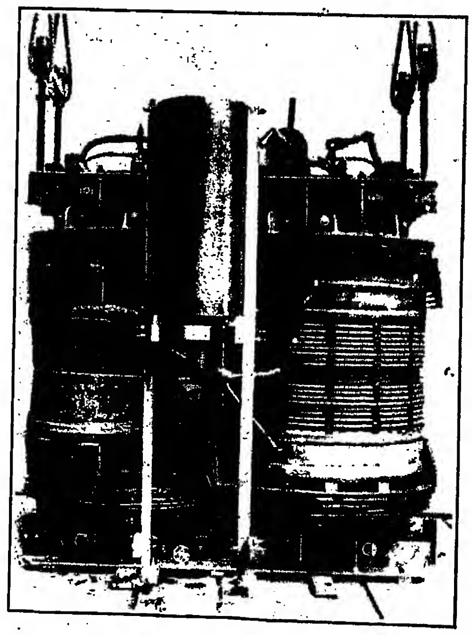

Fig. 29—Non-Resonating 20,000-Kv-a. 132,000-Volt Transformer

through respective C_p to a given element will be exactly equal to the current through the shunt capacitance C_s of that element to ground. In such a case, the charging current through all series capacitances will be equal

and the voltage across them alike. This would hold true, of course, at all frequencies.

As the protecting condensers are so proportioned that the voltage divides equally between the series capacitances, the initial voltage would be a straight line the final distribution is also a straight line (as all L's are alike),—therefore there can be no transient.

b. Test Data. Extensive tests were made on some power transformers with damped oscillations of frequency ranging from 3 to 1000 kilocycles, as well as with impulse waves of various shapes. The results are summarized on Fig. 20.

In practise, the condenser arrangement C_P consists simply of a smooth metal surface or a small number of such surfaces properly spaced and insulated from ground and the windings, and connected to the line terminal of the protected winding. These surfaces are called "shields."

They are located on the outside of the high-voltage windings, so as not to interfere with its usual construction. Fig. 29 shows a power transformer of the non-resonating type. So far, the non-resonanting type has been adopted for more than half a million kv-a. of transformers.

3. Effect of the Transformer Bushing.

The capacitance of the bushing is in shunt with the transformer, and is of the order of 0.0002 microfarads, which corresponds to the capacity of 0.15 of a mile of transmission line. This value is so negligibly small that it can have no effect on transient voltages within a transformer.

4. Choke Coils, Current Transformers, etc.

When a concentrated inductance such as a choke coil, current limiting reactor, current transformer, etc., in series with transformers, is struck by a traveling wave of steep front or tail, it enters into oscillations with the electrostatic capacity of the transformer. In this way, dangerous internal voltages may be set up in the transformer if it is of the ordinary design.

The author wishes to acknowledge here that in the preparation of this paper the interest and assistance of Mr. F. F. Brand have proved invaluable. The valuable assistance of Mr. J. H. Hagenguth in the preparation of data is also recognized.

Abridgment of

Street Railway Power Economics
On the Cincinnati System

BY J. A. NOERTKER*

Associate, A. I. E. E.

Synopsis.—Within the past few months, the Cincinnati Street Railway Company has completed the rehabilitation of its entire power system. The system now consists of 19 full automatic synchronous converter substations upon which has been superimposed a complete system of supervisory control and remote metering. Papers have been presented by Frank W. Peters and Harley L. Swift, covering the details of this installation.

This paper discusses the economic factors involved in the selection of equipment and the design of the system. Part I points out that the most important economic consideration is service and presents a method for evaluating this factor. Part II discusses the design of feeder circuits with particular reference to the limitations of Kelvin's Law. Part III discusses system design with reference to the economics involved in the location of substations, and in the selection of control equipment. A general method for conducting extensive system studies is implied. Part IV discusses system load-shifting characteristics and Part V points out the advantages of supervisory control.

INTRODUCTION

THE management of a modern street railway system, especially one operating under a "service at cost" franchise, should and does aim to provide a service that most nearly meets the requirements of the average car-rider; which implies, the fastest schedule speeds consistent with safety and ultimate economy. As a matter of fact, ultimate economy, as it concerns both car-rider and company, is one of the most important considerations.

The car-rider is interested in continuity, cost and quality of service. The primary factor affecting the quality of service is speed of car operation, and some idea of the magnitude of this factor may be had by considering that in a city of the size and character of Cincinnati, the total annual time spent by the car-riding public in transportation is approximately 50,000,000 hr.

It is practically impossible to determine definitely a value for this time; however, assuming a rate of 50 cents per hour, the annual amount will be $25,000,000, which amount is of sufficient magnitude in the interest of both the car-rider and the management to urge a careful analysis of all factors affecting the speed of car operation. Among the many factors affecting the

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speed of car operation, outstanding are: (1) Topography; (2) traffic congestion and control; (3) number and duration of stops; (4) rates of acceleration and retardation; (5) motor characteristics; (6) trolley voltage.

Two of these factors, motor characteristics and trolley voltage, are directly under the control of the railway engineers. In selecting car equipments, it is necessary to assume average conditions of the above factors. The

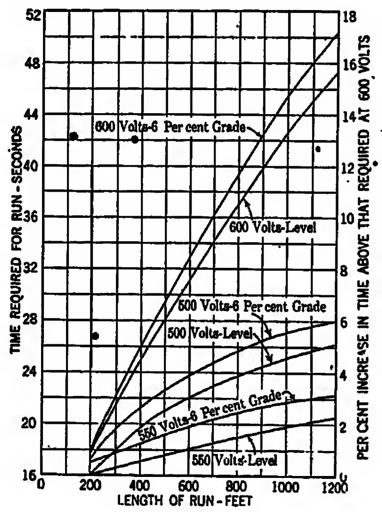

FIG. 1—MINIMUM TIME REQUIRED TO MAKE VARIOUS RUNS (WITHOUT COAST) AT 600 VOLTS, AND PERCENT INCREASE IN TIME AT LOWER VOLTAGES

Car Data—Motors—4 W. E. No. 510 E. hp. 35
Gear Ratio—13.69
Size of Wheels—26 in.
Wt. of Car and Load—19.36 tons
Acceleration—1.5 mi. per hr. per sec.
Retardation—2.0 mi. per hr. per sec.

proper voltage has also usually been determined for average conditions and in the design of the power system the effort has been to furnish this average voltage over the entire system. It is not certain, however, that an average voltage will fulfill all conditions in the most effective manner. Since the primary function of the power system is to furnish the most economical and satisfactory trolley voltage for the operation of the cars, it is of first importance to determine what voltage or voltages are the most economical and satisfactory for various operating conditions and then provide such voltage through the means of variable converter characteristics and transformer taps.

While poor voltage conditions may result in loss of time by passengers, aside from the evaluation of this time, it can be shown that for a city the size of Cincinnati, the annual variable cost of power supply subject to manipulation on which there is no practical check is approximately $180,000.00. This is made up of carrying charges on feeders, conversion loss, demand loss, energy loss, and carrying charges on that portion of the conversion equipment required to supply the feeder loss.

From this fact alone it is evident that a thorough study of the power system is justified.

In an effort to determine the proper voltages for the operation of cars under various conditions, the following curves have been plotted from the data derived from speed—time and power—time curves of the latest type cars of The Cincinnati Street Railway Company.

Fig. 1 shows the minimum time required to make various runs at 600 volts and the per cent increase in time at lower voltages. It will be observed that for runs of less than 200 ft., the minimum time required to make the run is approximately the same.

Fig. 2 shows the energy consumption required to make various runs at several different voltages. The curves show that increasing the voltage on these runs materially increases the energy consumption.

Fig. 3 is derived from Figs. 1 and 2 and presents the same information in a more convenient form for a 300-ft. level run and a 1200-ft. run on 6 per cent grade.

Fig. 4 shows the most economical trolley voltages for a 300-ft. level run and a 1200-ft. run on 6 per cent grade, with platform expense and evaluated time of car-rider taken at $10.00 per car hour and energy cost at the car taken as 1.5 cents per kw-hr.

Inasmuch as increased car speed has been looked

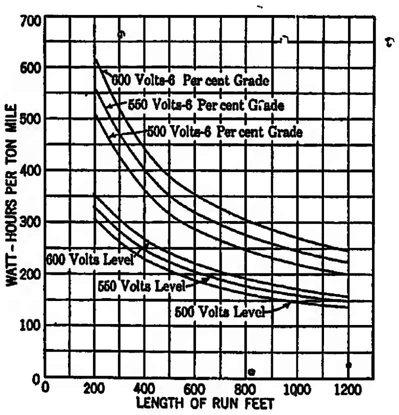

FIG. 2—ENERGY REQUIRED TO MAKE VARIOUS RUNS (WITHOUT COAST) AT VARIOUS VOLTAGES

Car data—same as Fig. 1

upon as the desirable result of increasing trolley voltage, no consideration has been given to the effect of coasting.

II. DISTRIBUTION SYSTEM

Feeder Sizes. The application of Kelvin's Law to railway power circuits has been presented in a paper by Crecelius and Phillips. (See Bibliography, complete paper). The following equations and curves present a convenient method for applying this law to extensive system studies. The most variable factor in such a study has been considered to be the cost and value of installed copper.

The total annual cost of a feeder circuit is equal to

the annual investment charge plus the annual demand loss charge plus the annual energy loss charge. This may be expressed as a mathematical statement as follows:

$$C_p = (r_1 \, Cu \, 10^{-2}) \, (3.67 \, m \, D \, 10^{-6})$$
$$+ \left(\frac{M + r_2 \, C_s \, 10^{-2}}{\text{Eff. (s. p.)}} \right) \left(\frac{I^2 \, 11.0 \, D \, 10^{-3}}{m} \right)$$
$$+ \left(\frac{e}{\text{Eff. (av.)}} \right) \left(\frac{8760 \, I^2 \, 11.0 \, D \, L \, 10^{-3}}{m} \right) \quad (1)$$

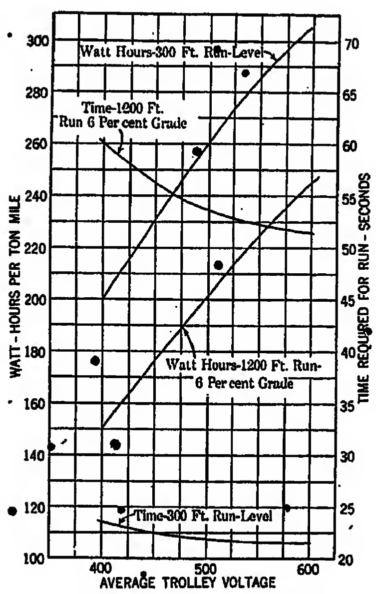

FIG. 3—TIME AND ENERGY CONSUMPTION REQUIRED (WITHOUT COAST) FOR 300-FT. LEVEL RUN AND 1200-FT. RUN ON 6 PER CENT GRADE

Car data—same as Fig. 1

where

C_p = Total annual cost of positive feeder circuit (dollars)

r_1 = Rate of return on feeder investment (12 per cent). (Taxes 2.0 per cent; Depreciation 2.0 per cent; Interest 6.0 per cent; Reserve 2.0 per cent)

Cu = Cost of insulated feeder in place (dollars per lb.)

3.67 = Pounds per ft. 1,000,000-cir. mil cable triple braid, weatherproof insulation

m = Cross-section of feeder at substation end (cir. mils)

D = Distance in feet to end of feeder or neutral point of feeder common to two or more stations

M = Annual maximum demand charge (dollars per (a-c.) kw. metered at 13,200 volts—$12.00)

Eff. s. p. = Efficiency of substation during peak load (0.93)

r_2 = Rate of return on substation investment (15 per cent). (Taxes 2.0 per cent; Insurance 0.5 per cent; Depreciation 4.5 per cent; Interest 6.0 per cent; Reserve 2.0 per cent)

C_s = Cost of substation per (d-c.) kw. capacity ($40.00)

I = One hour maximum demand (amperes)

11.0 = Ohms per cir. mil ft. 30 deg. cent. 98 per cent conductivity

e = Energy charge on purchased power (dollars per (a-c.) kw-hr. $0.004)

Eff. (av.) = Average efficiency of substation (0.90)

8760 = Hours in a year

L = Loss factor—the ratio of the average of the squared current demands to the squared maximum hourly current demand (0.25)

Substituting the above values in the equation for total annual cost and combining terms, the equation reduces to

$$C_p = 0.44 \times 10^{-3} \, Cu \, m \, D + \frac{0.32 \, I^2 \, D}{m} \quad (2)$$

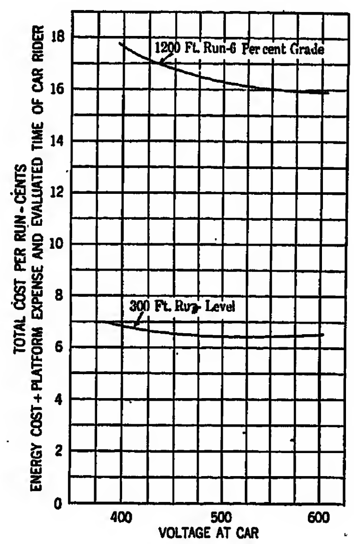

FIG. 4—TOTAL COST FOR SEVERAL RUNS (WITHOUT COAST) AT VARIOUS VOLTAGES

Car data—same as Fig. 1
Energy Cost—1.5 cents per kw. hr.
Platform expense and evaluated time of car-rider $10.00 per car-hr.

Equating first derivative to zero for minimum annual cost

$$O = 0.44 \times 10^{-6} \, Cu \, D - \frac{0.32 \, I^2 D}{m^2}$$

$$m = \frac{850 \, I}{\sqrt{Cu}} \quad (3)$$

This is the proper size feeder for minimum annual cost for concentrated load at the end of a feeder of uniform cross-section.

Copper losses caused by a distributed load on a theoretically tapered feeder are equal to one-half those

caused by a concentrated load on a feeder of uniform cross-section if this cross is the same as that at the station end of the tapered feeder. Since the volume of the tapered feeder is one-half that of the uniform feeder, the investment charge is one-half that shown by the equation for the uniform section with concentrated load.

The annual charge for this type of feeder is

$$C\,p = \frac{0.44 \times 10^{-6}\,Cu\,m\,D}{2} + \frac{0.32\,I^2\,D}{2\,m} \qquad (4)$$

and the cross-section for minimum cost becomes

$$m = \frac{850\,I}{\sqrt{Cu}} \qquad (5)$$

Also, since it can be shown mathematically that the copper losses caused by a distributed load on a feeder of uniform cross-section are equal to one-third those caused by a concentrated load, the annual charge for such a feeder is

$$Cp = 0.44 \times 10^{-6}\,Cu\,m\,D + \frac{0.32\,I^2\,D}{3\,m} \qquad (6)$$

and the cross-section for minimum annual cost becomes

$$m = \frac{850\,I}{\sqrt{3}\sqrt{Cu}} = \frac{490\,I}{\sqrt{Cu}} \qquad (7)$$

It is of particular interest to note that the proper size feeder for minimum annual cost, equation (3) is directly proportional to the load, and does not depend on the length of the feeder. All of these equations are applicable to the positive feeder circuit on both single and double trolley systems.

Reconcilement to Kelvin's Law. After feeder sizes have been determined by Kelvin's Law, the resulting average feeder voltage should be checked against the most economical voltage required for the operation of the cars. If the average voltage at the load as determined by Kelvin's Law is considerably above or below that required for the most economical car operation as shown by curves similar to those of Fig. 4 for the average runs on the section in question it will be necessary to plot graphs of equation (2) (total annual cost against average voltage at the load). This graph should then be superimposed and added to the appropriate curve on Fig. 4. The resulting graph will indicate the point of over-all minimum cost. The corresponding feeder size can then be read directly from the curves.

Tie Feeders. A comparison of equations (9) and (10) shows that the total annual cost of the uniform cross-section feeder is 15.7 per cent higher than that of the tapered section. In actual practise, due to the impossibility of obtaining a theoretically tapered section, this percentage is somewhat less. It is considered, however, that the advantages of the uniform cross-section feeder are worth the increased cost. This fact can be proved conclusively through the evaluation of power outages mitigated by the use of tie feeders.

III. Conversion System

Converter and Transformer Characteristics. It is evident that in so far as possible, the railway power system should provide the most satisfactory and economical trolley voltage. Since adjustment of voltage through the manipulation of the distribution system does not supply an economical method for varying voltages, it is up to the substation engineers to provide for this by making use of either adjustable machine characteristics or suitable transformer taps, or both.

There is no argument as to the superior performance of shunt converters from the standpoint of substation operation and system stability, but it must be recognized that shunt converters cannot be used in outlying territories or on heavy grades except at the sacrifice of car speed. In congested areas, advantage can be taken of the superior operating characteristics of shunt converters with the additional advantage of power saving brought about through the furnishing of more economical trolley voltages. For the same reasons, it will be desirable to provide transformer taps with the idea of varying d-c. bus voltage. Two distinct advantages resulting from this practise are (1) the providing of a more satisfactory trolley voltage, and (2) the providing for emergency load shifting.

Manual vs. Automatic Control. Among the important factors that determined the type of control selected for the Cincinnati power system were maintenance and operating costs; cost of equipment; reserve capacity; efficiency; reliability; improved service; protection of equipment and load shifting characteristics.

From a careful study of maintenance and operating costs and cost of equipment, it is apparent that automatic control has a decided economic advantage only in the case of new single unit stations.

Due to load shifting characteristics and thermal protective devices, automatic equipment can safely be subjected to heavier loads than could the corresponding manual equipment. Hence, it can be seen that less reserve capacity is required, and that efficiency may be increased. The reserve capacity required for double unit stations is particularly affected.

A definite improvement to service, due to automatic control, is the increased speed with which service is restored after having been interrupted by the failure of the high-tension power supply or by faults on the d-c. feeder system.

Since the bearing, thermal and ground devices on the automatic-control equipment provide protection superior to that possible with manual control, this must be considered an advantage.

The advantage of the load shifting equipment provided as part of the automatic control is one of the most outstanding benefits and should be given considerable weight in selecting control equipment for any railway application.

V. Supervisory Control

The primary functions of supervisory control are (1) to provide necessary checks on operation of substations, (2) to operate the system at the point of maximum efficiency and (3) to change the normal automatic functions so as to better meet emergencies.

Inasmuch as the entire 600-volt feeder system is tied together so that the loss of any one substation during the light load periods has little affect on the movement of cars, it is apparent that without some sort of indicating system, there is at this time no check on substation functioning. As most faults occurring in automatic substations develop or become apparent during the starting operation, it is of particular advantage to have a check at this time so that the faults may be remedied before the peak period.

Since the load demands on a street railway system are approximately the same from day to day, it is possible to

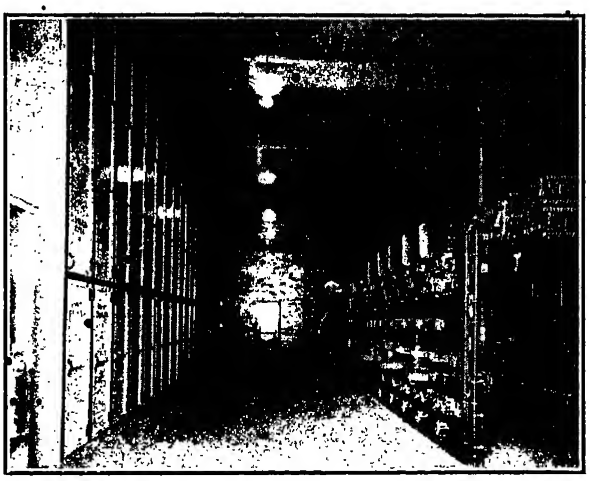

Fig. 11—Interior of Single Unit Automatic Substation

calculate the most efficient way in which to operate the system. This will usually call for a definite schedule for the various units.

In addition to providing the means for meeting fire and storm emergencies, the supervisory system can often be used to meet emergency overload conditions. These are usually taken care of by automatic equipment through the cutting in of the load shifting resistance which, as before stated, results in power loss, impaired service, and the possibility of overheated resistors. Frequently, improved service will result from dropping tie-feeder loads, since this may permit the reclosing of the resistance shunting contactors.

Remote Metering. As applied to the Cincinnati power system, the remote-ammeters provide the dispatcher with a continuous check on the operating conditions of the converters, both when starting and running. The ammeter, although calibrated to read in d-c. amperes, really measures the current in the a-c. side of the converter. The load readings are essential if the dispatcher is to shift loads during emergency overload conditions. The recording voltmeters provide a continuous check on that most important operating factor substation bus voltage.

Conclusion

Inasmuch as topography, arrangement of the city, density of population and traffic conditions have such a definite bearing on the distribution of load and car operation, it is impossible to draw conclusions that are generally applicable to all railway systems. In any city, however, the comprehensive design of a power system must consider as one problem the effect of trolley

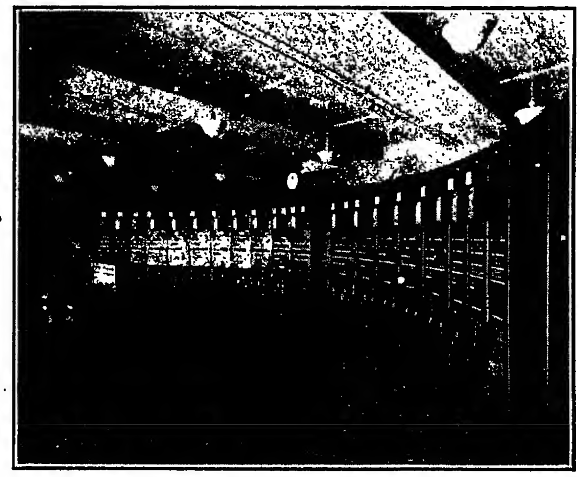

Fig. 13—Supervisory Control Room

voltage on car speed, the distribution system, the location of substations and the selection of conversion equipment.

a. On any railway system, the effect of trolley voltage on service is of most important consideration and merits a more extensive study than has yet been given to it.

b. Kelvin's Law with certain limitations is generally applicable to the design of railway feeders and offers a relatively simple solution to the problem of the determination of proper feeder sizes.

c. Converters and transformers designed to give the greatest possible flexibility as to operating voltage should be selected. Compound-wound converters capable of being operated as shunt machines are most suitable for the railway power system, the flat voltage characteristics being desirable for grades and outlying territories and the shunt characteristics being more desirable for congested areas.

d. The use of automatic control results in the most economical and reliable system.

e. With a complete automatically-controlled system it is necessary to have some sort of check on substation operation. Supervisory control, in addition to providing such a check, furnishes a method for more efficient normal and more effective emergency operation than is possible with full automatic equipment acting alone.

Abridgment of

Recent Development in Telephone Construction Practises

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and

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Synopsis.—In this paper are described recent developments in telephone construction practises which react to preserve the integrity of the sheath of lead-covered cable, thus decreasing insulation troubles due to moisture seeping through armor breaks and warding off serious service interruptions.

* * * * *

Introduction

GROWTH of the telephone plant in the last few years has naturally followed the tremendous increase in the use of this method of communication. The outside plant which has been built to satisfy these increased requirements is very largely composed of either aerial or underground cable.

The extension of the toll cable network, where in several hundred telephone and telegraph messages a carried within a lead-antimony cable sheath of approximately 2⅝ inch diameter, and the development of exchange cable in sizes up to 1818 pairs of wires, has necessitated new construction practises intended to keep the sheath intact, thereby lessening service interruptions.

These new construction practises are the results of development work throughout the country and are as follows:

1. Gas pressure testing of cable to locate sheath openings.
2. Methods of erecting aerial cable in order to minimize bowing.
3. Long span construction.

Gas Pressure Testing

With the extension of the toll cable network, it has become necessary to provide a definite plan of preventive maintenance whereby potential troubles may be eliminated. In this connection, the introduction of gas under pressure into a cable is not a new departure, but the kind of gas and the apparatus for applying it, have undergone considerable development and improvement in the past three years.

Equipment

Oil pumped nitrogen has been adopted as the most suitable gas for pressure testing. It is supplied by the manufacturer in 55-in. cylinders. These cylinders are usually used on large construction projects inasmuch as one 55-in. cylinder will test approximately 6000 ft. of full size cable.

In order that small amounts of gas may be available for testing single splices, a 25-in. cylinder which contains sufficient gas to test eight or nine 4½-in. sleeves is also used.

Standard gas pressure gages are used with these

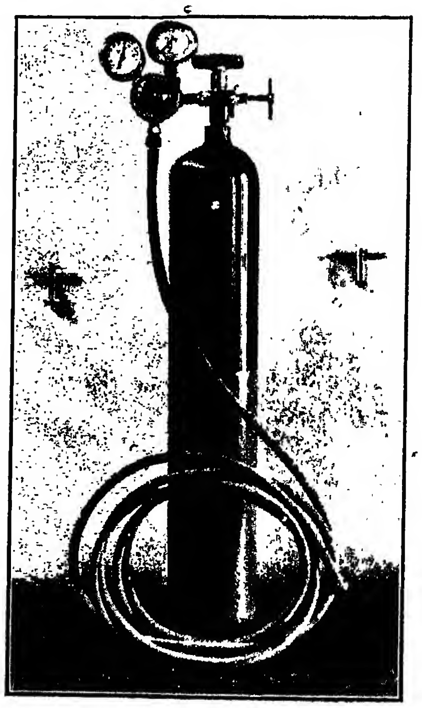

FIG. 1—SMALL CYLINDER GAS PRESSURE EQUIPMENT
Showing regulating equipment, valves and awl.

tanks and with the equipment shown in Fig. 1, they fit into wooden carrying cases which are issued to the splicers.

Single Splice Tests

In testing single splices, two holes are made with an awl, one near each joint end of the sleeve. A valve stem and a 30-lb. gage are screwed into these holes and the hose from the gas tank is attached to the valve stem. The entire sleeve and both joints are covered with thick soapsuds and then the gas turned on and allowed to flow into the sleeve at an ingress pressure of 40 lb. The gas is prevented temporarily from flowing through the cable by the paraffin in the cable ends which was deposited while "boiling out" the splice with hot paraffin to improve the insulation. When the pressure on the screw-in gage reaches 5 lb. the gas is turned off

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at the tank. The sleeve and joints are then examined with a magnifying mirror for bubbles which indicate leaks. Large leaks are located by the hissing of the escaping gas. If a joint leaks, it is rewiped and the gas testing operation is repeated.

Testing Long Lengths of Cable

On new cable projects, the usual procedure is to splice the cable in loading sections of 6000 ft. and to gas-test the section as a unit. Just before the loading is cut in, the ends of the section are capped and gages are installed at each end. At the loading point where the two ends of different sections appear, valve stems are fastened into the end caps and connected to a large cylinder of gas by means of a two-way hose. The nitrogen is permitted to flow into both sections simultaneously at a 40-lb. rate until the meters at the far extremities register 5 lb. The gas is then turned off and all meters are read as soon as possible.

If the reading at one end is appreciably different from that at the other, or if they are equal but lower than the average at the time the tank was disconnected, it is probable that one or more defects exist, and that they are in the duct line in the case of underground cable, or in the section between the splices on aerial cable.

Several methods of locating this type of trouble have been used with fair degrees of success. On aerial cable where it is possible to ride the entire section under test, the first step is usually to cover the section with the intention of hearing the hiss caused by escaping gas and to inspect the cable from the ground for any bends, kinks or flaws which would be soaped to locate possible troubles.

If this method is unproductive, the next step would be to install a gage in each splice in the section. As full size cable is usually erected in 750-ft. sections, there would be seven splices in a 6000-ft. section in which meters would have to be installed, making a total of nine points at which the internal pressure could be read. The pressure readings would then be recorded on cross section paper. Theoretically, if the cable was free of defects, these points would lie in the same straight line and defects would be indicated by low points on the curve.

The curves shown in Fig. 2 give an example of the method of locating trouble in a typical 10-mi. section. From Curve 2-*A* defects exist in the vicinity of poles 980, 785 and possibly near 530. The defect near pole 980 will be located more accurately.

The method is to extend the converging slopes of the curve at the low point and the defect will be found near the location represented by their intersection. The readings at poles 1109, 1046, 980 and 915 are laid off to a larger scale (Curve 6-*B*) and the lines drawn through these points intersect near pole 1002. The foregoing represents an actual case, and the trouble was found in a leaky sleeve at that point.

This same procedure is used in locating defects in underground cable where the sheath break occurs in the duct line. The defect would be located between the manholes at which the lowest pressures are recorded.

Constant Pressure Testing

This system of pressure testing has been very effective and quite a number of the more important toll cables have been placed under constant pressure.

After the cable has been cut into service, all lateral taps and both terminal ends are sealed with dams or plugs to prevent the escape of gas. In addition to plugging the cable at the ends and lateral taps, intermediate plugs are installed at approximately 10-mi. intervals, in order to sectionalize the cable to assist in locating sheath breaks. Valve stems are first located

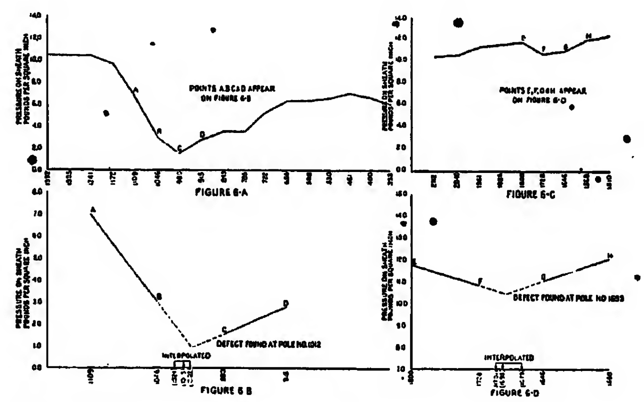

Fig. 2—Graphic Method of Locating Sheath Breaks

Typical pressure curve for section of aerial cable having two sheath breaks

Note: One 200 cu. ft. cylinder of nitrogen is sufficient to test a 6000 ft. section of cable

at the loading splices which gives them a 6000-ft. spacing. Enough gas is then introduced into the cable to give an equalized pressure of 15 to 20 lb. throughout the length.

In order to have a means of detecting loss of pressure after the section has been inflated for sometime, electrical indicating gages associated with an alarm circuit are placed in each ten mile section. The alarm is set to operate when the internal pressure falls below 12 lb. The alarm circuit operates a lamp signal or bell in the central office or repeater station and a cable man is immediately dispatched to locate the trouble by aforementioned methods.

Clearing Trouble

Another use of nitrogen in maintenance work results from the drying effect of the gas when admitted on either side of a wet cable fault. In certain instances, this method not only has restored the telephone service in a wet cable while a new section was being pulled in but it has aided the splicers in toning through the defective section when cutting over. It is reasonably certain however that only in those cases where the cable is partially wet, can it be dried out completely with gas.

Aerial Cable Construction

New methods which, it is felt, will decrease troubles

and lower maintenance costs have recently been developed for placing and splicing aerial cable.

Cause and Theory of Bowing

The causes of bowing in full sized aerial cable supported on 16-M suspension strand have been determined. Measures for the prevention of bowing have been worked out theoretically and have been put into practise in the field with satisfactory results. Fig. 3 illustrates a typical bow in a large cable.

The generally accepted theory of the cause of bowing is as follows: Due to a difference in the coefficients of expansion of suspension strand and cable, the cable expands more than the strand under the influence of a rise in temperature. The length of strand and cable in any span is assumed to be equal at the time the cable is spliced. As the temperature rises above the splicing temperature, the cable expands faster than the strand

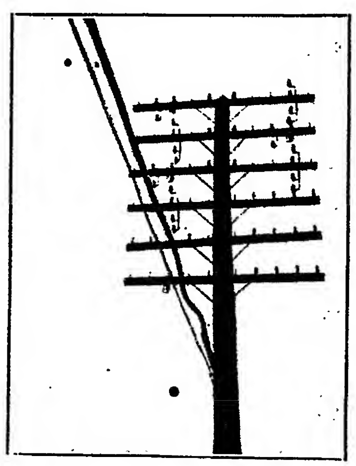

Fig. 3—Typical Bow in a Large Cable
This condition will eventually cause a sheath break at the wipe

and, as it cannot move along the line, compression is set up within the cable. When this compression exceeds the resistance of the cable to bending, the cable bows out of line. The amount of compression and bowing depends upon the extent to which the temperature has risen above the splicing temperature.

Under the influence of a drop in temperature, the cable will contract faster than the strand and when the temperature falls below that at which the cable was spliced, tension is developed in the cable. The tension which will develop at the minimum temperature of the locality depends on the temperature at which the cable is spliced. If the cable was spliced at a high temperature, the tension developed during extremely cold weather may stretch it permanently to some extent. As a result, when the temperature rises again to the original splicing temperature, the cable instead of being once more free of stress, will be under compression and as the temperature rises still further, bowing will occur sooner than it would have if it had not been permanently stretched.

Construction Methods to Minimize Bowing

As a result of studies and field trials of full sized cable supported on 16-M strand, the following construction methods have been recommended for new aerial cable so as to minimize bowing:

1. *Reduced Strand Tension.* This method is the reducing of the initial strand tension of 16-M strand from 6400 lb. (60 deg. fahr.) to 3600 lb. (60 deg. fahr). The theory is that a high initial strand tension reduces to a considerable extent the normal (or unstressed) elongation or contraction of the strand with temperature change. Therefore, if the initial strand tension is reduced, the loaded strand tension will be reduced and will permit an increased elongation and contraction with temperature change. As a result, the changes in strand length become more nearly equal to the changes in cable length, and the tendency for the cable to bow is reduced. Field trials have shown that the reduction in strand tension practically eliminated all bowing in those cases where the cable was spliced at a temperature of approximately 40 deg. fahr. or above.

2. *Placing Strand at Correct Tension.* In order to permit the field forces to string suspension strand more easily and more nearly at the correct initial tension, an instrument called the "Strand Dynamometer" has been developed. This instrument may be placed on the suspension strand at any point without cutting or otherwise injuring the strand and will indicate the tension existing in the strand at that point.

3. *Placing Cable so that it is Free from Waves.* In order to prevent bowing it is necessary to have the cable the same length as the strand when it is first placed in the rings. An "Aerial Cable Guide and Straightener" has been developed which eliminates in a large measure any waves which may be in the cable as it comes off the reel. The tool consists of a sheet iron shoe terminating in a steel tube of slightly larger diameter than the cable. The cable is pulled over this shoe and through the tube before it reaches the rings.

4. *Preventing Cable from Being Spliced While the Strand is in a Stretched Condition.* Splicing is ordinarily done from platforms which support one or two workmen and their equipment. This extra weight will stretch the strand and as a result, after the cable is spliced and the weight of the splicers and their equipment is removed, the strand will contract and some excess cable will remain in that span. This stretching of the strand has been prevented by supporting the temporary weight with a ladder which is tied to the strand alongside the splicing point before erecting the platform.

5. *Placing Tension in the Cable.* At temperatures of 40 deg. and below it has been found that the above measures are not sufficient to prevent the cable from bowing when the temperature subsequently rises to the neighborhood of 100 deg. fahr. Accordingly the practise has been developed of placing tension directly in the cable before splicing by means of a "Tension

Splicing Tool" and holding it there until the splice is completed.

The effect of tension is to reduce the amount of expansion in the cable and thereby bring the amount that the cable will expand under a given temperature rise closer to the amount that the strand will expand. The amount of tension placed in the cable varies with the temperature existing at the time the splice is made. For temperatures just under 40 deg. the tension is small, but for temperatures as low as 20 deg. below zero, the tension is about 1500 lb. This method has prevented bowing in cables spliced at temperatures as low as 5 deg. below zero.

Removing Bows in Old Cable

Two methods have been investigated for removing the bows in cable which has been erected and spliced for some time. They are:

1. Pull the excess length of cable to concentration points and cut out.
2. Cut suspension strand at intervals, introduce excess strand at these points, and slack off until bows disappear.

Where the bows are removed by cutting out the excess cable length, some tension remains in the cable after being pulled to the concentration points but the strand tension is not materially reduced. Therefore, during hot weather, the tension in the cable tends to reduce the bowing while the high initial strand tension tends to promote it. Consequently the results obtained in this matter are not as successful as the results obtained by slacking off the suspension strand at various intervals, which method places the cable in tension and reduces the strand tension simultaneously.

Another advantage of Method 2 over Method 1 is that slacking off the strand does not require that the working cable be opened whereas in pulling tension in the cable it must be cut to remove the excess length. Inasmuch as the comparative costs of the two methods are approximately the same, slacking off the strand appears to be superior to cutting excess length out of the cable, as a method for removing bows from cables supported on 16-M strand. Cutting the excess length out of bowed cables has its application to those cases where the strand tension is low, the cable is badly bowed, and the existing clearance above ground is such that no material increase in sag can be permitted.

Long Span Construction

A "Long Span" in the telephone plant refers to any span longer than the normal 150 ft. and ranging up to and in excess of 1000 ft. Due to the physical characteristics of telephone cable, especially its low tensile strength, it is necessary to support it with steel strand (called the "messenger") from which the cable is suspended by means of hangers spaced 20 in. on center.

Two types of construction have been adopted for long spans:

1. The catenary type where a suspension guy relieves the messenger strand of the larger part of the load. The theory of the loaded catenary is not new but its application to the telephone plant is of recent development. Fig. 4 illustrates the catenary type.
2. Using high-strength steel messenger strand to carry the total weight of the cable. Fig. 5 illustrates an elongated simple span.

Economic considerations are the determining factor in deciding the length of span which can be justified in a given case. Catenary construction is used in our toll cable plant largely as a matter of convenience and as a means of carrying the cable suspension strand across streams or other barriers continuously without dead-ending. On the other hand a long span was built about a year ago, and more are projected, where the length of the span is in excess of 1000 ft. and in which the cable suspension strand alone carries the entire stress and no catenary construction is used: The latter are cable spans inserted in open wire lines at river crossings and the cable terminates on the crossing poles.

Advantages

Long span construction, under certain conditions, has distinct advantages, especially where there is an obstacle to clear, such as a river.

The simpler type of long span involving high-strength

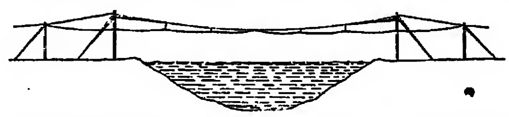

Fig. 4—Long Span Employing Catenary Construction

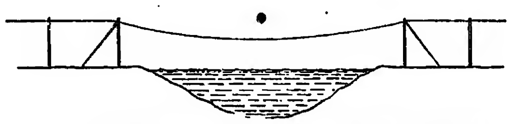

Fig. 5—Typical Elongated Simple Span

messenger has several advantages over the catenary type. Theoretical considerations indicate that less bowing will occur in the simpler type of long span. Also, this type permits construction with somewhat smaller sags. As a matter of fact, with the same total number of steel strands used, slightly smaller sags could be obtained by hanging the strands and cable in one long span than if catenary construction were used. This is for the reason that the messenger strand will carry a greater proportion of the weight of the cable in the long span.

Conclusion

Eliminating service interruptions with their resultant inconvenience to subscribers, embarrassment to business, loss of revenue, etc., due to cable failures justifies far reaching measures.

It is felt that definite progress has been made towards building cable plant whose sheath continuity will be undisturbed except from extraneous or foreign influences. Further advances can probably be realized by pursuing the methods and developing the ideas presented.

Abridgment of

Iron Losses in Turbine Generators

BY C. M. LAFFOON* and J. F. CALVERT*

Associate, A. I. E. E. Associate, A. I. E. E.

Synopsis.—In large turbine generators, there is no convenient method for determining the iron losses under load. It is the purpose of this paper to show, analytically, the factors influencing the change in iron loss with load; that on the basis of the flux distributions, the machines can be most conveniently divided into end zones, which present three dimensional problems, and a large central zone, which presents only two dimensional problems. The losses in each part are discussed qualitatively, and the losses in the central zone are obtained quantitatively for an ideal machine in which only the fundamentals of the flux waves are present. Contrary to the usual view, these losses do not vary as the square of the generated voltage, but are predominantly affected by the ratio of the slot to total leakage reactance. The results are given in curves. The complications in the problem introduced by the usual commercial designs by non-sinusoidal field forms, phase bands, etc., are discussed qualitatively.

THE best conception of the factors producing iron loss in turbine generators can be obtained by investigating the flux distributions in the different parts of the magnetic circuit. The end zones will be discussed briefly and then the central zone in greater detail. Figs. 1, 2, and 3 indicate diagrammatically the direction of the flux in the plane passing through the center lines of the magnetic poles. There is a convenient division of the fields into end zones and a central zone. In the end zone it is necessary to consider the flux distribution as a three-dimensional problem where-

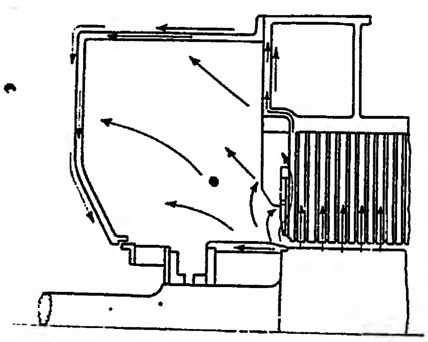

FIG. 1—FLUX DISTRIBUTION IN CENTER PLANE OF THE POLE-ROTOR EXCITED ALONE

as in the central zone it can be considered as a two-dimensional problem.

It is necessary to decide between just what two radial planes two-dimensional conditions may be assumed. An estimate of this was made by assuming a simplified magnetic circuit as shown in Fig. 4. Fig. 5 has been drawn in an attempt to give a three-dimensional picture of these conditions. It is probably reasonable to assume that the end effects are confined to the first three packets on each end and that the large central zone presents only two-dimensional problems.

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1. For references see Bibliography.

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DISCUSSION OF THE STATOR IRON LOSSES

It is the large central part of the stator iron which will be discussed in this article. For calculation an ideal machine which has the following characteristics will be considered:

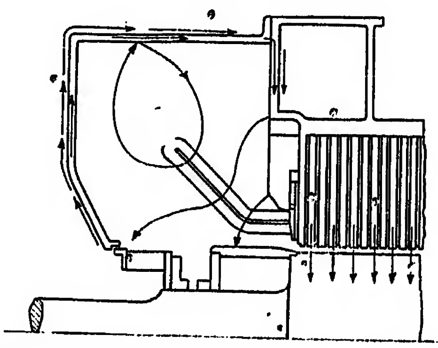

FIG. 2—FLUX DISTRIBUTION IN THE CENTER PLANE OF THE POLE, STATOR EXCITED ALONE

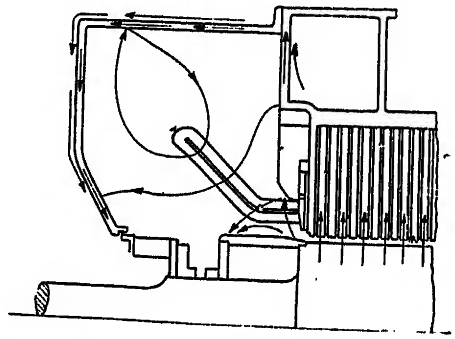

FIG. 3—FLUX DISTRIBUTION IN THE CENTER PLANE OF THE POLE, BOTH ROTOR AND STATOR WINDINGS EXCITED AT THE FULL-LOAD, ZERO POWER FACTOR, OVER-EXCITED CONDITION

1. A large number of teeth will be assumed, so that practically no tooth taper is present;

2. There will be as many phases as slots per pole so that the fundamental of the slot leakage flux may be considered alone; and

3. A full-pitch winding will be assumed.

In addition to the above assumptions for a special

machine, the following general assumptions will be made:

4. The rate of eddy-current loss in watt-seconds per second per unit volume will be assumed proportional to the square of the instantaneous value of the resultant flux density in the laminated iron;

5. The hysteresis loss per cycle will be assumed proportional to the square of the maximum flux density for the conditions encountered in commercial machines; and

6. No allowance will be made for the redistribution

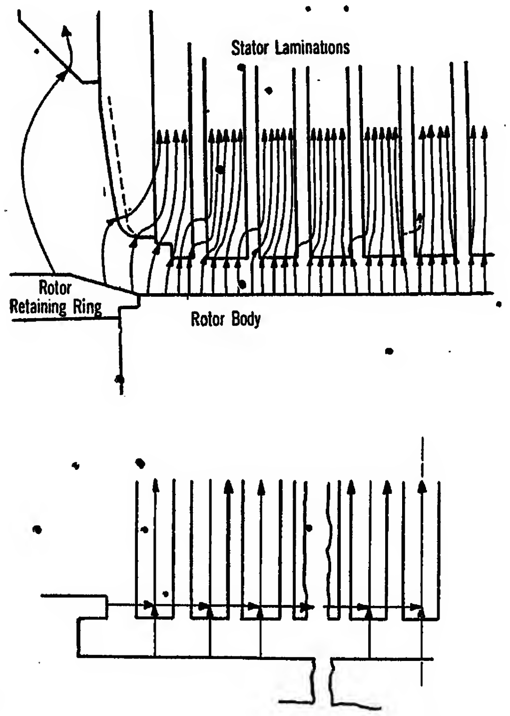

FIG. 4—PATHS ASSUMED IN ESTIMATING THE AXIAL PENETRATION OF END FLUX

of the flux in the main magnetic circuit due to changes in permeability between no-load normal voltage and full-load normal voltage conditions.

It is intended to consider the factors involved by the variations in the stator teeth and core loss on load as compared with the no-load conditions, due to the fundamental of the cross slot leakage flux and the increase or decrease in the air-gap flux. On all loads which require over excitation, the air-gap flux must be increased to produce a generated voltage equal to the vector sum of the terminal voltage and the armature leakage reactance voltage. Conversely, for practically all under-excited conditions, the air-gap flux is less at the load than at the no-load full-voltage condition.

The armature leakage reactance voltage is usually divided into two main parts,—the voltage due to the end winding flux, and the voltage due to the slot leakage flux. (In this machine there will be no "tooth tip leakage flux," because no higher harmonics have been assumed.) The end winding reactance flux influences the densities in the main magnetic circuit, because it usually necessitates a change in the air-gap flux to maintain constant terminal voltage. It has been explained, previously, that the effect of the end winding flux, as such, can be neglected when considering densities in the central part of the stator iron. The reactance

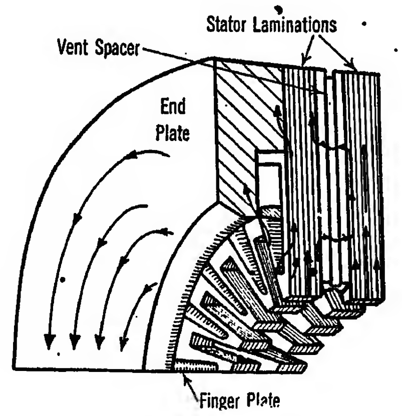

FIG. 5—FLUX IN THE STATOR END PARTS

produced by the armature slot leakage flux also necessitates a change in the air-gap flux in order that constant terminal voltage shall be maintained. However, the paths of the latter flux (Fig. 8) are through the same stator iron parts as are occupied by the air-gap flux.

LOSS IN THE CORE

It is now possible to estimate the relative losses in the core back of the teeth on the basis of the foregoing

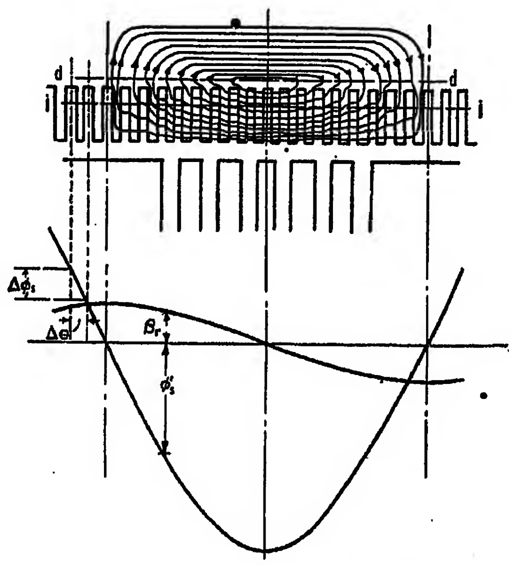

FIG. 8—ASSUMED DISTRIBUTION OF ARMATURE SLOT LEAKAGE FLUX

assumptions. Both the air-gap flux, ${}_1\Phi_a$, and the radial component of the slot leakage flux, $2\ \Phi_s$, have sinusoidal distributions at some circumferential line $d - d$, as shown in Figs. 8 and 9. These components of flux combine to give a resultant sinusoidal flux wave so that on the basis of assumptions 4, 5, and 6, it follows that the ratio of core loss on load to that on no load must be

$$\frac{{}_1W_c}{{}_0W_c} = \left\{ \frac{{}_1\Phi_a + \overline{2\,\Phi_s}}{{}_0\Phi_a} \right\}^2 \qquad (1)$$

In this case the vector quantity $\overline{2\,\Phi_s}$, is in phase with the maximum radial density due to the cross slot flux.

Loss in the Teeth

The changes in tooth loss with load are much more difficult to describe than the core loss, but can be illustrated with drawings. The difficulty is that the air-gap and slot leakage flux distributions do not have the same general shape in the teeth, whereas they did have in the core. In the teeth, the armature windings establish both tangential and radial densities, while the air-gap field produces only radial densities. (See Figs. 8 and 9). Hence, the tangential density and the resultant radial density must be known at every point in the tooth throughout one cycle. Obviously, at every instant of time, the resultant density squared is equal to the sum of the squares of the tangential and the resultant radial densities.

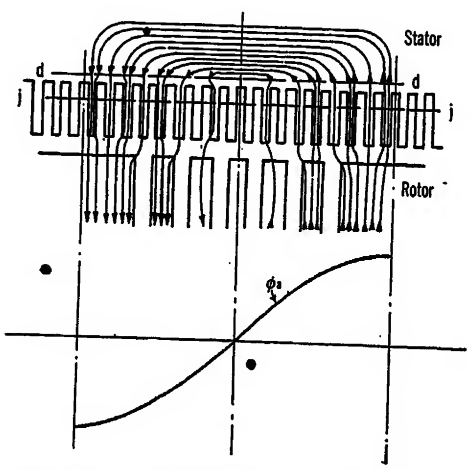

Fig. 9—Assumed Distribution of Air-Gap Flux

$$\beta_T^2 = \beta_R^2 + \beta_s^2 \qquad (2)$$

The rate of eddy-current loss per unit volume per cycle is proportional to the mean square value of the resultant density, $\frac{1}{\pi}\int_{\theta=0}^{\theta=\pi} \beta_T^2\, d\,\theta$, but,

$$\frac{1}{\pi}\int_0^{\pi} \beta_T^2\, d\,\theta = \frac{1}{\pi}\int_0^{\pi} \beta_R^2\, d\,\theta + \frac{1}{\pi}\int_0^{\pi} \beta_s^2\, d\,\theta \qquad (3)$$

Hence, the eddy-current loss due to the density components displaced 90 deg. in space may be computed separately and added.

The rate of hysteresis loss per cycle is proportional to the maximum density squared.

Figs. 30 and 31 give the total variations in iron loss with load as functions of power factor. Various ratios of slot to total reactance and two values of total per cent reactance are chosen as shown. Certain ratios for the loss on no-load were assumed, as follows:

$$\frac{\text{No-load core loss}}{\text{Total no-load iron loss in the machine}} = \frac{{}_0W_c}{{}_0W_T} = 0.6$$

$$\frac{\text{No-load eddy-current loss in the teeth}}{\text{Total no-load iron loss in the machine}} = \frac{{}_0W_{et}}{{}_0W_T} = 0.1$$

$$\frac{\text{No-load hysteresis loss in the teeth}}{\text{Total no-load iron loss in the machine}} = \frac{{}_0W_{ht}}{{}_0W_T} = 0.3$$

All curves apply to the large central zone in the stator and are for four-pole machines.

I. Ratio of the core loss on load to that on no-load.

$$\frac{{}_1W_c}{{}_0W_c} = 1 + 2\left(\frac{I\,X_t}{E_t}\right)\sin\gamma + \left(\frac{I\,X_t}{E_t}\right)^2$$

$$- 3\left(\frac{I\,X_s}{E_t}\right)\left(\frac{I\,X_t}{E_t} + \sin\gamma\right) + \frac{9}{4}\left(\frac{I\,X_s}{E_t}\right)^2. \qquad (5)$$

(Note that $\cos\gamma$ = power factor.)

This includes both hysteresis and eddy-current loss.

II. Ratio of the eddy-current loss in the teeth on load to that on no-load.

$$\frac{{}_1W_{et}}{{}_0W_{et}} = 1 + 2\left(\frac{I\,X_t}{E_t}\right)\sin\gamma + \left(\frac{I\,X_t}{E_t}\right)^2$$

$$-2\left(\frac{I\,X_s}{E_t}\right)\left(\frac{I\,X_t}{E_t} + \sin\gamma\right) + \left(\frac{I\,X_s}{E_t}\right)^2\left(\frac{3}{K_3^2} + \frac{6}{5}\right) \qquad (6)$$

III. Ratio of the hysteresis loss in the teeth on load to that on no-load.

$$\frac{{}_1W_{ht}}{{}_0W_{ht}} = \frac{1}{2}\,\frac{{}_1W_{et}}{{}_0W_{et}}$$

$$+ \frac{1}{2}\int_{\frac{x}{l}=0}^{\frac{x}{l}=1} \sqrt{\begin{aligned} &\left\{ \cos^2\gamma - \left(\frac{I\,X_t}{E_t} + \sin\gamma\right)^2 \right. \\ &+ 3\left(\frac{I\,X_s}{E_t}\right)\left(\frac{I\,X_t}{E_t} + \sin\gamma\right)\left(1 - \frac{x^2}{l^2}\right) \\ &\left. - \frac{9}{4}\left(\frac{I\,X_s}{E_t}\right)^2\left[\left(1 - \frac{x^2}{l^2}\right)^2 - \frac{4}{K_3^2}\,\frac{x^2}{l^2}\right] \right\}^2 \\ &+ \left\{ 3\left(\frac{I\,X_s}{E_t}\right)\left(1 - \frac{x^2}{l^2}\right) \right. \\ &\left. - 2\left[\frac{I\,X_t}{E_t} + \sin\gamma\right] \right\}^2 \cos^2\gamma \end{aligned}}\; d\left(\frac{x}{l}\right) \qquad (7)$$

It should be remembered that certain design constants must be involved in the numerical constants of these equations. For instance, the ratio of the iron area for the cross slot flux to that for the radial flux must be introduced, and it depends upon the physical proportions of the machine. (See the list of symbols under Notation for the value k_3).

General Conclusions

In the central portion of the ideal generator (which has only fundamental flux waves), the ratios of iron loss

on load to those on no-load are not only functions of total reactance and power factor, but also of the ratio of slot to total reactance.

The actual loss in these parts is considerably less at operating conditions than is calculated by the usual

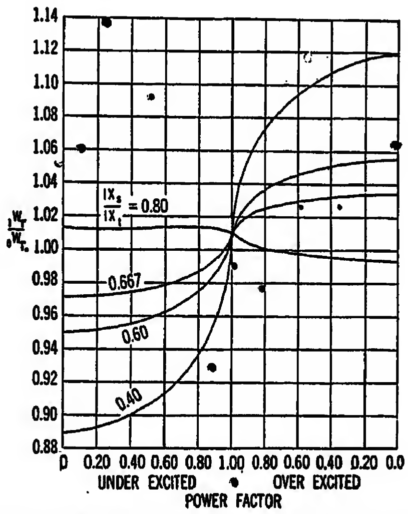

FIG. 30—RATIO OF FULL-LOAD STATOR IRON LOSS *vs.* POWER FACTOR FOR FOUR-POLE TURBINE GENERATOR WITH $\frac{I\,X_t}{E_t} = 0.12$

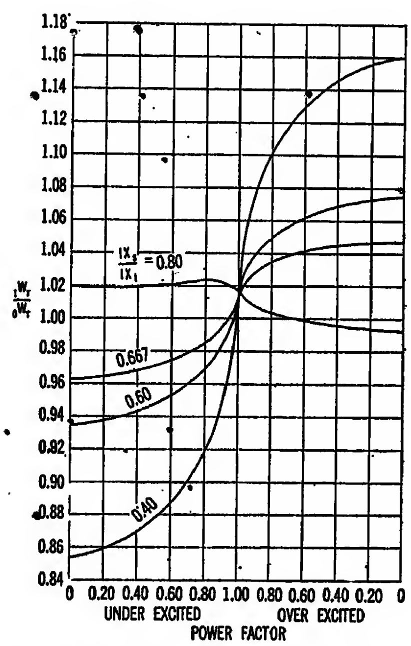

FIG. 31—RATIO OF FULL-LOAD TO NO-LOAD STATOR IRON LOSS *vs.* POWER FACTOR FOR FOUR-POLE TURBINE GENERATOR WITH $\frac{I\,X_t}{E_t} = 0.16$

where IX_s = slot leakage reactance
IX_t = total leakage reactance
E_t = terminal voltage

method wherein the assumption is made that the iron loss varies as the square of the generated voltage. This is illustrated in Figs. 30 and 31. If a machine has a ratio of slot to total reactance of about 0.7, there is practically no variation in iron loss with load.

The quantitative analysis of the variations in iron loss for an actual commercial machine is vastly more complicated than for the ideal generator in the central portion of the stator, and some of the factors cannot be considered at all. These are discussed in the unabridged copy of the paper.

It is possible to make analytical calculations for the loss in certain of the end zone parts. For instance, if the flux distribution in the end-bell iron can be established, a two dimensional problem may be assumed within the metal. However, the effect of the axial flux in the stator fingers, end plates, and first two or three packets, probably, can be investigated properly only by tests which will permit the separation of the end zone from the central zone losses. Tests on machines of different lengths could be used if it could be established that the loss per inch axially in the central zone was substantially the same in each test; and not at variance due to building differences.

ACKNOWLEDGMENTS

The writers are indebted to Messrs. L. A. Kilgore, A. M. Harrison, and H. C. Myers of the Power Engineering Dept. for valuable theoretical assistance and for calculating data for the curves.

NOTATION

Flux Symbols

${}_1\Phi_a$ = resultant air-gap flux per pole on load at normal voltage.

${}_0\Phi_a$ = air-gap flux per pole on no-load at normal voltage.

Φ_s = maximum flux across any one slot due to the armature windings.

φ_s = instantaneous value of Φ_s.

φ_s' = instantaneous value of cross slot leakage flux between any circumferential line $j - j$ in the teeth and the teeth tips.

β_s = instantaneous tangential density at any point in a tooth due to the armature cross slot leakage flux.

β_R = instantaneous resultant radial density at any point in a tooth.

Voltage and Current Symbols

(All values are per phase)

E_t = terminal voltage.

$I\,X_t$ = total armature leakage reactance.

$I\,X_s$ = armature slot leakage reactance.

Loss Symbols

${}_1W_c$ = total loss in the stator core on load.

${}_0W_c$ = total loss in the stator core on no-load.

${}_1W_{et}$ = eddy-current loss in the teeth on load.

${}_0W_{et}$ = eddy-current loss in the teeth on no-load.

${}_1W_{ht}$ = hysteresis loss in the teeth on load.

${}_0W_{ht}$ = hysteresis loss in the teeth on no-load.

${}_1W_T$, and ${}_0W_T$ = total iron loss in the machine on load and on no-load, respectively.

Angular Symbols

θ = angular displacement with respect to some one point on the stator. Counterclockwise rotation is assumed.

θ = $2\pi \times$ frequency $\times$ time)

γ = power-factor angle and is assumed positive when the current lags the terminal voltage.

Dimension Symbols and Constants

x = radial distance from the base of the slot toward the tooth tip.

l = total depth of slot.

D = diameter at stator tooth tips.

P = number of pairs of poles.

A_p = total area of cylindrical surface at the tips of the teeth.

A_i = total area of magnetic material in the cylindrical surface at the tips of the teeth.

K_2 = stacking factor.

K_3 = constant for a given machine.

$$\left(K_3 = \frac{A_p}{A_i} \; \frac{2\,P\,K_2\,l}{D}\right)$$

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Abridgment of

Cathode Ray Oscillograph Study
Of Artificial Lightning Surges on the Turners Falls Transmission Line

BY K. B. McEACHRON* Member, A. I. E. E. and V. E. GOODWIN* Associate, A. I. E. E.

Synopsis.—A portable impulse generator delivering 400 kv. has been constructed. A cathode ray oscillograph of the cold cathode type has been so connected that impulses incoming over the transmission line to which it is connected will initiate the oscillograph.

The results of studies on a 5.77-mi. section of a 66-kv. line of the Turners Falls Power Company are given. Impulses of definite forms are applied to the line. The theory of traveling waves is being checked experimentally, demonstrating the existence and magnitude of reflections, both for open-ended lines and for lines closed through gaps or a combination of inductance and capacity. A simple description of the theory is given.

Some preliminary results are given for attenuation obtained by successive reflections from either end of the line.

The reduction of the incoming waves by an oxide film lightning arrester is given, the affected wave in one case having a front of six microseconds and in another case a front of 0.5 microseconds.

Further work to be done includes the effect of traveling waves on choke coils, transformers and ground wires. Additional work is to be done to determine the laws governing attenuation.

* * * * *

THE equipment required consists essentially of cathode ray oscillograph equipment which can be set up and operated in the field, and an impulse generator which is easily moved along the transmission line as desired.

The oscillograph[1] is the cold cathode type[2] which is not suited to continuous operation unless the cathode potential is kept low, which interferes with its ability to record high-speed transients, photographically. Therefore one of the first requirements in the use of this oscillograph for transient registration is that means must be provided for exciting cathode at the time of the occurrence of the transient.

When endeavoring to record lightning surges on a transmission circuit, it is necessary that the incoming transient set off a trip circuit which will excite the cathode and complete necessary connections so that the oscillograph is in operation within, perhaps, a millionth of a second after the voltage at the oscillograph begins to rise due to the incoming transient.

With a study such as that being described in this paper, it is desired to obtain oscillograms of natural lightning transients as well as records of the man-made lightning transients; the circuits therefore are arranged to be operated either way.

In Fig. 1 the cathode ray oscillograph circuit shown at the right is initiated at the same time that a small impulse is sent out by the oscillograph operator on the lower conductor of the transmission line. This impulse reaches the impulse generator shown at the left and causes the three electrode gap to spark over. Since

*Both of the General Electric Co., Pittsfield, Mass.

1. For all references see Bibliography.

Presented at the Regional Meeting of the Middle Eastern District of the A. I. E. E., Cincinnati, Ohio, March 20-22, 1929. Complete copies upon request.

the impulse generator is kept charged, the generator circuit will be tripped by the operation of the three electrode gap, and the discharge of the impulse generator takes place, sending out an impulse on the middle wire of the transmission line.

This impulse reaches the cathode ray oscillograph whose cathode stream has already been established

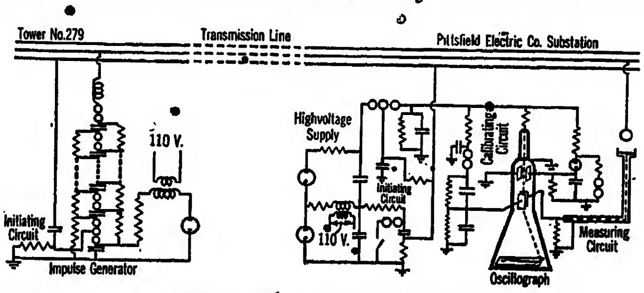

FIG. 2—CIRCUIT FOR APPLYING TRANSIENTS TO A TRANSMISSION LINE

Arranged to pre-excite the oscillograph so that the entire wave-front may be obtained

and the change in potential at the deflecting plates of the oscillograph is recorded as in Fig. 7.

In case the oscillograph is to be operated by a transient due to lightning, the initiating circuit is modified, the three-electrode gap at the oscillograph being connected to the transmission line through a capacitance potentiometer.[7] When the transient itself initiates the oscillograph, because of the time delay in getting the oscillograph under way the initial portion of the incoming transient is lost. (Such an oscillogram is given in Fig. 10 of the complete paper.)

THE TRANSMISSION LINE

The transmission line on which these tests are being made consists of a double circuit, and extends from the Pittsfield Silver Lake Substation to the Cabot Station of the Turners Falls Power Company on the Connecticut River. The total length of circuit is 36.7 mi., passing over rather hilly country in western Massachusetts.

The line was built for 110-kv. operation, but is now operating at 66 kv. The average height of line at the tower is 71 ft. for the top conductor. At points (five) along the line, disconnecting switches have been provided. Tests have been made only at Tower 279 which is located a distance of 5.77 mi. from the Silver Lake Substation.

IMPULSE GENERATOR

The impulse generator is designed to deliver a crest potential to ground of 400 kv. Sixteen oil capacitor units are charged in parallel and discharged in series making use of the Marx[3] circuit as indicated in Fig. 1. The generator has a capacity of 0.0156 μ f., the stored energy being 1250 watt-seconds.

Tests have been made with two wave fronts, one a fast wave reaching its crest in about ½ microsecond, and the other, a slower wave rising to its crest in about 6 microseconds.

Fig. 5 shows the impulse generator at the base of Tower 279 with the connections made, and the disconnects open. The illustration shows the line extending over the hills to Pittsfield and gives a fair idea of the type of country traversed by this line. The cathode ray oscillograph is located at the Silver Lake Substation.

LINE CHARACTERISTICS

In order that a proper understanding of the principles involved may be obtained by the reader, two oscillograms are given in Fig. 7 which will be discussed in some detail. The circuit diagram is given under each oscillogram. It should be noted in both cases that the impulse generator and the cathode ray oscillograph are both at the Pittsfield end of the line. Also in both cases the disconnects are open at Tower 279, 5.77 mi. away. In the upper oscillogram there is no apparatus connected at tower 279, while in the lower oscillogram a sphere-gap which arced over is connected between line and ground.

The oscillograms are alike and may be superimposed up to the point where the gap sparked over. These

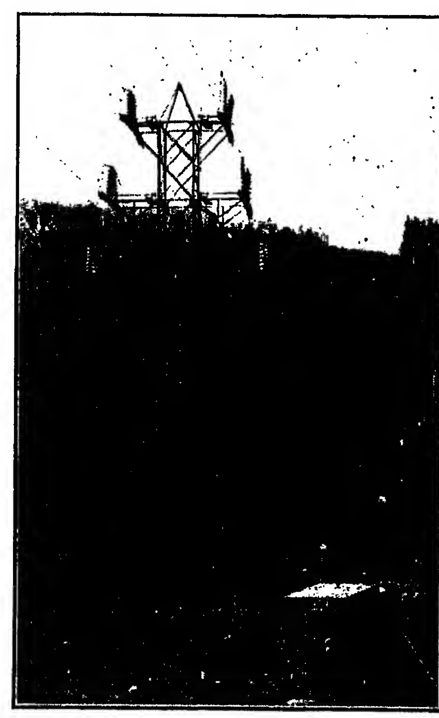

FIG. 5—TOWER 279—SHOWING PORTABLE IMPULSE GENERATOR

Line in foreground extends to Pittsfield

oscillograms show the initiation of the oscillograph by the transient itself, which is the reason for the missing portion of the front of the wave.

TRAVELING WAVES

A proper understanding of the oscillograms in Fig. 7 requires some knowledge of how such waves travel on transmission lines.

A wave travels along a line by charging up the capacity of the line as the voltage is increasing on the front of the wave, and discharging the line capacity as the voltage decreases on the tail of the wave. Such

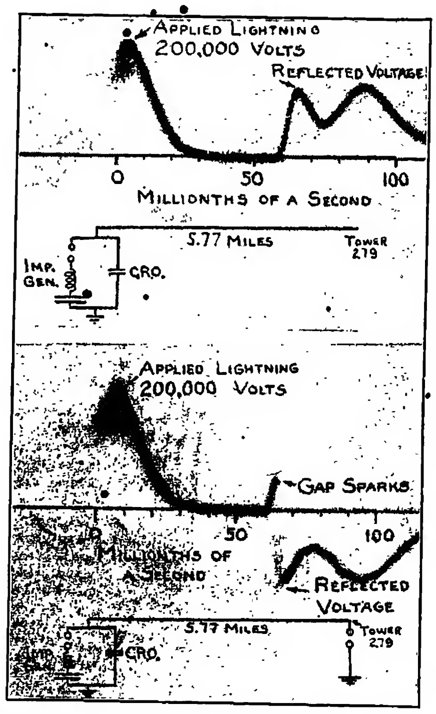

Fig. 7—Oscillograms Showing Initial and Reflected Waves with Impulse Generator and Oscillograph Both at Silver Lake Substation

Upper oscillogram open ended line at Tower 279
Lower oscillogram line closed through gap at Tower 279

a process requires that the wave form of current exactly correspond to the wave front of voltage.

When such a wave is traveling along a line, two equal energies need be considered; one is electromagnetic and is stored in the magnetic field around the conductor due to the transient current, and the other energy is electrostatic and is stored in the electrostatic field between the conductor and ground. If the wave meets with an open circuit at the end of a line, all of the energy at the open end becomes electrostatic, and the potential at the end of the line is doubled. Neglecting losses, the reflected wave will be identical with the original wave.

If the traveling wave meets a short circuit to ground, the electrostatic energy at the short circuit becomes zero and the electromagnetic energy is doubled, as is also the current in the short circuit. If the crest current of the traveling wave is I amperes, (which value is obtained by dividing the crest potential of the traveling wave by the surge impedance of the line), then the current in the short circuit will be two I amperes.

When a resistance equal to the surge impedance is connected between line and ground, the energy of the traveling wave is absorbed in the resistance with no reflection either of voltage or current.

An electrostatic capacity connected between line and ground acts first like a short circuit, and as it becomes charged, acts more and more like an open circuit. An inductance acts in the opposite manner, acting first like an open circuit and later as a short circuit. Thus when a traveling wave meets an inductance connected between line and ground, the potential rises, followed by a reversal of polarity as the inductance begins to act as a short circuit.

The effect of the circuit conditions used in taking the upper and lower oscillograms in Fig. 7 is shown in Figs. 9A and 9B. An impulse is seen traveling away from the impulse generator toward the open ended line. (Wave No. 1).

An oscillograph at the end of the line would have shown a volt—time curve such as that shown A (2) at

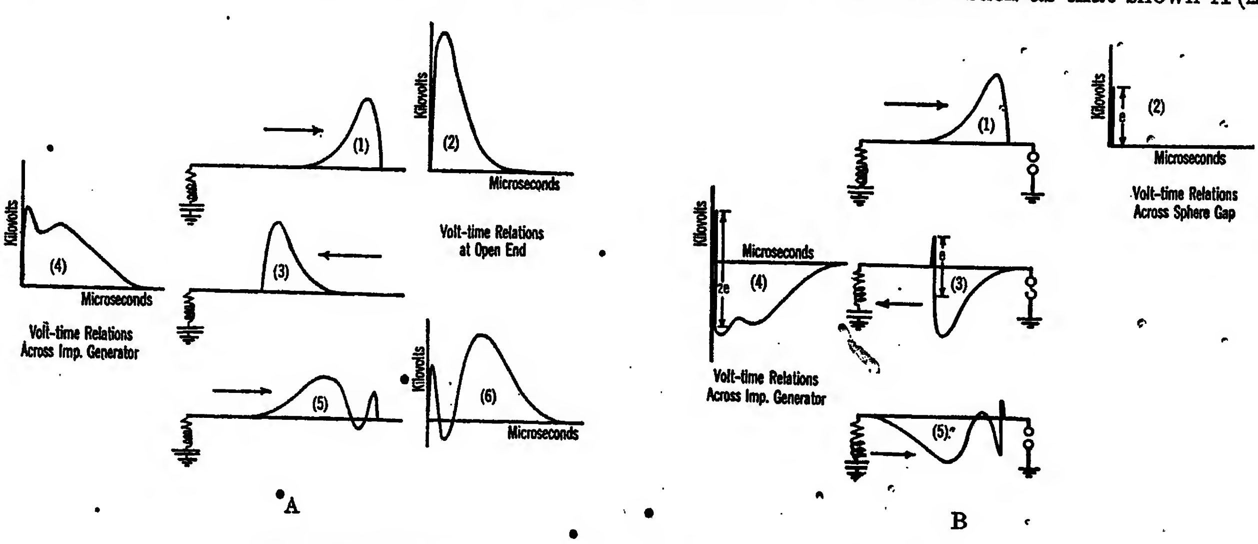

Fig. 9—Reflections with Impulse Generator at One End of Line

a. With open-ended line
b. Line closed through a gap set for e volts

the right. The reflected wave (3) is traveling back toward the impulse generator. With the line being considered, the reflected wave returns to the impulse generator in about 62 microseconds. In this short space of time the tests have shown that the gaps at the impulse generator are still ionized so that the impulse generator may be considered as inductance and capacity and resistance at the end of the line. The

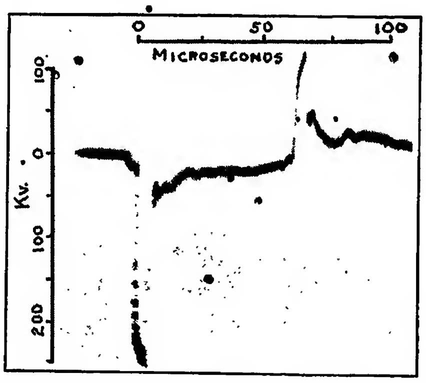

FIG. 11—CHOPPED WAVE-GAP SET AT 197-KV. CREST

voltage-to-ground across the impulse generator with respect to time is shown at the left (4), and corresponds to the reflection shown in the respective oscillograms of Fig. 7. This curve is the sum of the reflected wave (5) from the impulse generator and the reflected wave from the open end (3).

The wave (5) reflected from the impulse generator travels to the open end of the line where a reflection takes place as shown by (6).

In Fig. 9 an attempt has been made to set up con-

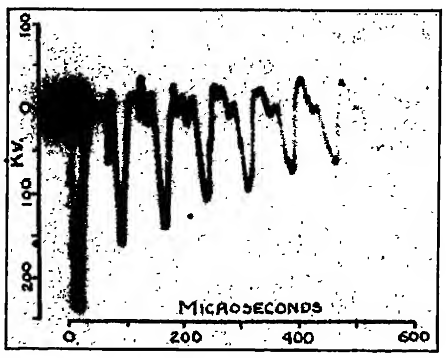

FIG. 12—SUCCESSIVE REFLECTIONS, FULL WAVE

ditions which would check approximately the oscillograms and also in such a manner as to be able to visualize how the reflections take place and show that inductance and capacity will give a form of wave similar to those observed. Mr. O. Brune has calculated these reflected waves by the methods of the operational calculus and his methods are outlined in a forthcoming article in the *General Electric Review*. He has been able to find quite satisfactory agreement with the oscillograms.

CHOPPED WAVES

Since in practise traveling waves are frequently cut off by flashover of insulators it is worth while to consider the effects of the line constants and apparatus on such waves.

The dotted curve in Fig. 16 shows a so-called full wave which rises to its crest in 6 to 8 microseconds, as determined by the use of a high-frequency oscillator which makes it possible to measure the front accurately. Since the impulse generator is at the far end of the line, the oscillogram shows the voltage rise at the station end of the line and thus is probably close to double the voltage of the traveling wave.

In Fig. 11 all conditions were unchanged except that a sphere-gap was connected between line and ground at the impulse generator and set to spark at about the crest of the wave. It is interesting to note how steep the cut-off is and that the reflection comes back reversed to the station end where the oscillograph is located,

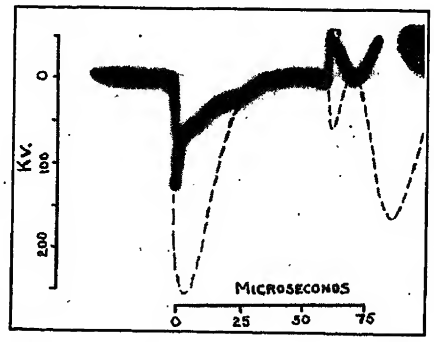

FIG. 7—ARRESTER PERFORMANCE CHARACTERISTICS ON 6-MICROSECOND FRONT

Dotted curve—impulse at oscillograph without arrester. (See Fig. 10)
Oscillogram—taken across 85 O F cells

which shows that the gap is still ionized. The sloping of the wave due to corona can be seen on the front of the reflected wave. When studying these oscillograms it should always be remembered that they represent voltage changes at the oscillograph with respect to time. From them, with proper interpretation, the traveling wave can be deduced.

ATTENUATION

The attenuation on lines is a matter of considerable importance in the protection of lines and station apparatus. It seems to have been quite definitely shown[4] that for dangerous voltages the attenuation depends largely at least on the effect of corona.

Some preliminary results are available on the short section of line worked with up to the present time.

The method of making these tests was to apply at tower 279 an impulse which reflected back and forth over the line which except for the small capacity of the oscillographic equipment and the station bus capacity was open at the oscillograph and closed to ground throught he impulse generator at tower 279. The

first two reflections measured by the oscillograph are shown by the dotted curve in Fig. 16. The oscillogram in Fig. 12 shows eight of these reflections, which corresponds to a length of line of approximately 85 mi.

Surge Impedance

Some preliminary work has been done in an effort to determine the surge impedance of the line. When the line is closed through resistance equal to the surge impedance no reflection will take place. By taking oscillograms of the voltage across the resistance, its value can be adjusted until the reflection disappears.

This method of determining the impedance does not give a very accurate result, but the oscillograms taken show that the surge impedance lies between 320 and 530 ohms. The calculated value of just the middle wire alone and one ground wire is 500 ohms. The effect of the other conductors is to lower the calculated value. The surge impedance may also be lowered by corona, and it is hoped that data will be securable which will determine this point.

With this line, it will be possible to determine the effect of stopping the ground wire some distance from the station and also the effect of additional ground wires near the station. The magnitude of voltages and currents will be studied with their relation to ground resistance of the tower footing. Thus it is expected that definite information regarding the benefit derived from additional ground wires from the standpoint of the effect on the surge impedance will become available.

Apparatus Characteristics

The effect on the incoming impulse of choke coils, lightning arresters, bushings and transformers, outgoing circuits, and the effect of station bus work is to be studied. The work with regard to all other apparatus except the lightning arrester is in too preliminary a state to give any results in this paper. Some very interesting results on an oxide film arrester are available.

Oxide Film Arrester

Since voltages comparable with the maximum allowed by the line insulation of six disks were not available, it was decided to reduce the size of the arrester to be tested to such a magnitude that it would have a potential applied comparable with what it might get in service.

The oscillogram taken across the arrester is shown in Fig. 16 together with the wave without the arrester, as shown by the dotted line. The potential has been reduced by the arrester and its duration has been greatly decreased. The arrester has changed a wave of dangerous potential and comparatively long duration into one of much shorter duration with a crest voltage safely below the strength of the parallel insulation.

Summary

1. Theory of traveling waves is being checked experimentally, demonstrating the existence and magnitude of reflections, both for open-ended lines and for lines closed through gaps or combinations of inductance and capacity. A simple discussion of the theory is given.

2. The effect on incoming waves of various pieces of apparatus, such as lightning arresters, choke coils, transformer bushings and the effect of busses or other transmission lines connected to the bus is being studied.

3. The effect of ground wires on attenuation is being investigated which includes the influence of additional wires near the station as well as the effect of stopping the ground wire several towers out from a station.

Acknowledgments

The authors wish to express to Mr. F. L. Hunt and others of the Turners Falls Power Company, and also to Mr. Granville Whittlesey of the Pittsfield Electric Company, their appreciation of the cooperation given in the investigation, and without which the work could not have been done.

The work of the investigation has been carried on by Messrs. E. J. Wade, W. J. Rudge, Jr., O. Brune and T. Brownlee. These men have all contributed largely in the design and construction on the impulse generator and the successful design of the oscillograph circuits, and the operation of the equipment.

The authors express to these men their appreciation for the service they have rendered both in connection with the investigation and the writing of this paper.

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ENGINEERING SOCIETIES EMPLOYMENT SERVICE

EXCERPTS FROM LETTERS OF APPRECIATION

December 30, 1928.

I am convinced that your method is a good one, even though I did not profit by it, and I will be glad to recommend it in the future to my friends.

I appreciated your kind and sympathetic handling of my case and will be glad to cooperate with you in the future, when I am in need of men.

November 7, 1928.

I am satisfied with my present conditions so would not be interested in following up the job in question.

November 7, 1928.

I was very much pleased with your Service and believe it well worth while, and want to thank you for the many courtesies shown me. Should I ever have reason to require or desire a change, I will get in touch with you.

Abridgment of

Lighting of Airways and Airports

BY H. E. MAHAN[1]

Associate, A. I. E. E.

Synopsis.—The Department of Commerce under the Air Commerce Act is responsible for the installation, operation, and maintenance of the national airways. The lighting facilities along the airways consist of revolving beacons at 10-mi. intervals and intermediate landing fields approximately every 30 mi. The intermediate landing fields, in addition to the revolving beacon, are provided with an illuminated wind cone, boundary, approach, and obstruction lights. The Department of Commerce is also responsible for the rating of airports, although their establishment, maintenance, and operation are matters of municipal or private concern. The rating of an airport is a measure of the facilities available. A preferred rating for lighting facilities requires the installation of an airport beacon to locate the airport from distant points, an illuminated wind direction indicator, white or yellow lights marking the boundary of the landing area, red lights on all obstructions, green range lights marking approaches, flood-lighted hangars or other buildings as a measure of altitude and to illuminate identifying markings, a searchlight for measuring ceiling height, and suitable floodlighting for the landing area.

In view of the regulating authority vested in the Department of Commerce, the practise in lighting airways and airports follows very closely established standards. The floodlighting of the landing area proper offers the greatest opportunity for original thought and ideas. There have developed two schools of opinion regarding the fundamentals of field floodlighting systems. One school favors the use of a single unit, or a group of units, at one location for floodlighting the field, which system is referred to as the centralized system. The opposing school, advocating two or more light sources placed at different locations about the field, is known as the distributed system. Both systems have in common the use of lighting units delivering a fan shaped beam of light only a few degrees wide in the vertical plane and varying from 45 deg. to 180 deg. in the horizontal plane.

The present lighting facilities are found very satisfactory during fair weather but the problem of aiding the flier during fog still faces the engineer and research scientist as a problem.

* * * * *

LAST year was celebrated the 25th anniversary of the first airplane flight of the Wright Brothers at Kitty Hawk, N. C. To-day, the Department of Commerce reports that there are 15,128 mi. of airways operating, and 1330 established airports in the country exclusive of Army and Navy fields. Of this number, 9341 mi. of airways, 274 intermediate fields and 74 other types of fields are lighted for night flying. By July 1, 1929 it is expected to have 11,270 mi. of lighted airways. This is truly a remarkable record of progress and a glance at the map (Fig. 1) indicates the present scope of organized air transportation.

Obviously, if such facilities are to be operated at the maximum of efficiency, the service must be continued throughout the twenty-four hours of the day, for it is the distance covered between the end of one business day and the beginning of the next one that gives air travel its greatest advantage over other forms of transportation. In other words, the movement of material and passengers during the night conserves daylight working hours, and the greater the distance that may be covered in this period, the greater the benefit realized.

Thus arises the problem of providing adequate lighting that will permit after-dark operations at our airports and along our airways. The author advances no original ideas for the solution of this problem, but merely outlines the practise followed at the present time in lighting and marking airports and airways for night flying.

1. Application Engineer, Illuminating Engineering Lab., General Electric Co., Schenectady, N. Y.

Presented at the Regional Meeting of the Middle Eastern District of the A. I. E. E., Cincinnati, Ohio, March 20-22, 1929. Complete copies upon request.

AIRWAYS

An airway is defined by the Department of Commerce as "An air route between air traffic centers with landing facilities at intervals equipped with aids to air navigation and communication system for transmission of

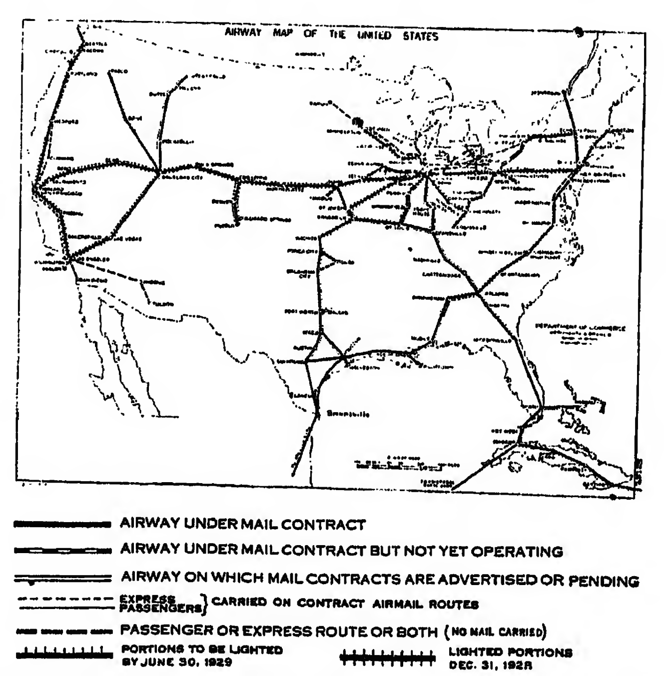


FIG. 1—AIRWAY MAP OF THE UNITED STATES SHOWING ROUTES LIGHTED AND TO BE LIGHTED

information pertaining to the operation of aircraft. The term 'airway' may apply to an air route for either land planes or sea planes, or both." Under the Air Commerce Act of 1926, the Secretary of Commerce has authority to establish and maintain civil airways

operate and maintain intermediate landing fields, lights, signal and radio direction finding apparatus and other structures and facilities (excepting airports) used as aids to navigation. In fulfillment of this obligation, the Department of Commerce has established along the airways, beacon lights at 10-mi. intervals and emergency landing fields at 30-mi. intervals.

The beacon (Fig. 3) consists of a 24-in. revolving

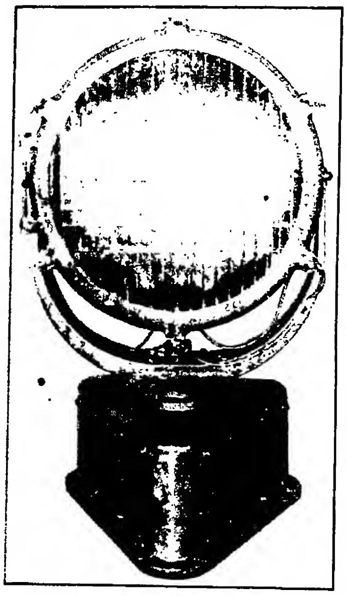


Fig. 3—Airport Beacon Conforming to Department of Commerce Specifications

incandescent searchlight equipped with a 1000-watt, 115-volt lamp and mounted on a steel tower. Automatic lamp changers are provided to replace a burned-out lamp with a new one held in reserve. The beacon is supplemented by two "course" lights consisting of 500-watt projectors, one facing in each direction along the airways. The course lights are flashed by a mechanism integral with the beacon mechanism and synchronized to flash the course light opposite to the position of the beacon along the airway. The flashes indicate in code the number of the beacon, and thus, to the pilot, his position along the airway. These course lights are equipped with red lenses where no landing field is available and a yellow lens where there is an intermediate field. Intermediate fields are equipped with a beacon, illuminated wind cone, boundary, approach and obstruction lights.

Airports

The Department of Commerce requires that an airport in order to obtain the highest (A) rating for its lighting facilities, must have the following equipment:

a. An airport beacon
b. An illuminated wind-direction indicator
c. Boundary lights
d. Obstruction lights
e. Hangar floodlights
f. A ceiling projector
g. Landing area floodlighting system

Items (a) to (d) inclusive must operate all night.

The function of the beacon is to mark the airport from distant points. In order to accomplish this purpose effectively, a light must be sufficiently distinctive to contrast with surrounding lights; it must have a distribution which makes it visible at all points on the horizon and nearly to the zenith, and be of sufficient beam candle-power to carry great distances.

In order to carry out the policy of indicating the landing conditions at beacons along the National Airway System, it is recommended by the Department of Commerce that a green flashing auxiliary beacon be placed above the principal beacon to indicate that there is an airport at that location.

It is very essential that the pilot wishing to land be apprised of wind conditions on the field. The wind cone is perhaps the most generally used device for giving this information as it not only indicates the direction of the wind but also an approximate idea of its velocity. A method of lighting a wind cone (Fig.

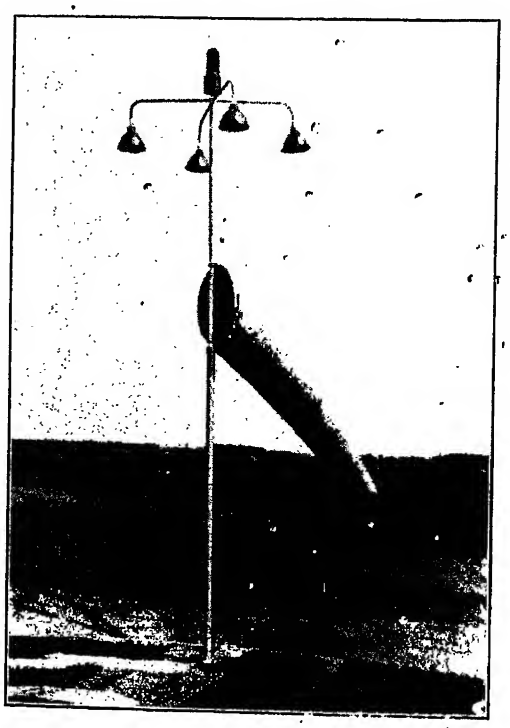


Fig. 4—Wind Cone Mounted on Roof of Hangar Showing Method of Lighting

4) consists of four 100-watt lamps in deep bowl porcelain enamel steel reflectors, grouped at right angles to each other on 2-ft. arms approximately 6 ft. above the wind cone. An obstruction light is placed on the top of the assembly. Another type of wind indicator (Fig. 5) is known as a wind tee and consists of a structure simulating an airplane and pivoted to change position with change of wind direction. It is illuminated at night by means of lamps placed on top of the

tee and "reflectored" so as to throw the light on the structure and shield the direct light from the eyes of the pilot.

The extent of the field is made known to the pilot by means of light sources placed around the border of the landing area on approximately 300-ft. centers. A type of unit used for this service (Fig. 6) consists of a weatherproof housing and etched clear globe enclosing a 600-lumen (60-c.p.) 6.6-ampere series lamp or a 25-watt multiple lamp.

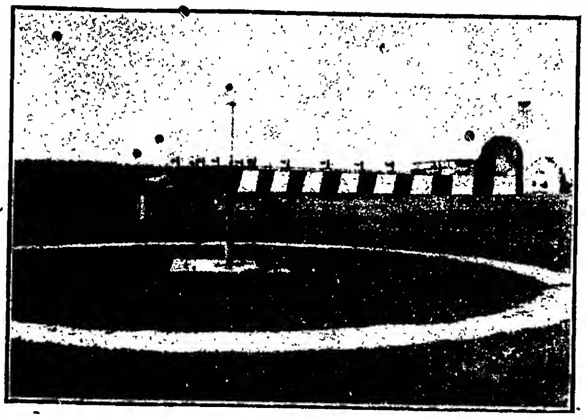


Fig. 5—Wind Tee

A wind direction indicating device illuminated by means of reflectored lamps on top of tee

A green globe is substituted for the clear, etched globe used on boundary fittings to serve as range lights for runways, or as markers for the most advantageous landing directions. Obstructions on or in the vicinity of the airport are marked with red lights placed at the highest point of the structure. It is also the practise at some airports to make obstructions visible to the pilot by floodlighting them. This is found particularly advisable in connection with the hangars for in addition to making the buildings visible, it makes evident their height, and in this way gives the pilot a measure of altitude. Such a system of lighting also provides illumination at the aprons of the hangar for the movement of planes and illuminates any signs or markings on the roof of the hangar. The illumination intensity recommended for hangar exteriors by the Department of Commerce is 2.5 foot-candles.

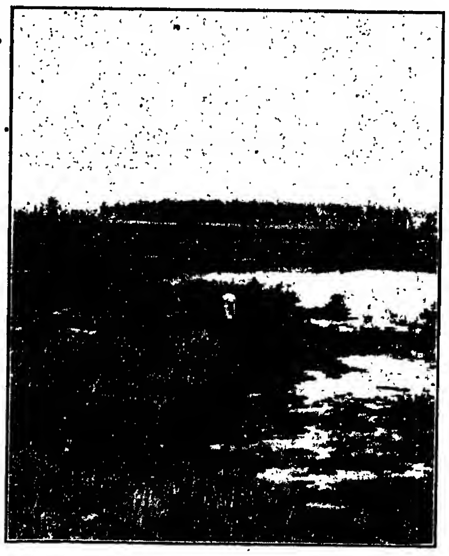


Fig. 6—A Form of Boundary Light Equipped with 600-Lumen 6.6-Ampere Series Incandescent Lamp

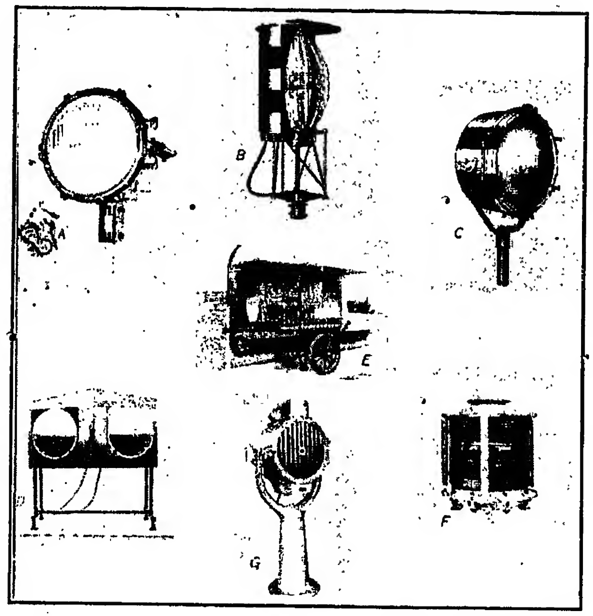


Fig. 9—Typical Forms of Airport Floodlighting Equipment

A. Incandescent Airport Floodlight. A 24 in. projector with chromium plated reflector and 45 deg. spread lens designed for use with 1500 watt and 3000-watt, 32 volt incandescent lamps.

B. Incandescent Airport Floodlight. Unit equipped with glass reflector designed to deliver a 180 deg. spread of light in the horizontal and limit the vertical spread to a few degrees. Lamp used may be either the 5-kw., 110-volt or 3000 watt, 32-volt incandescent lamp

C. Incandescent Airport Floodlight. Unit equipped with 25-in. mirrored glass reflector and spread convex heat-resisting lens of approximately 40 deg., 50 deg. or 80 deg. horizontal spread. Unit takes either the 1500 watt, 32 volt or 3000 watt, 32 volt incandescent lamp

D. Incandescent Airport Floodlight. Unit equipped with two 5-kw. or 10-kw. incandescent lamps, each in focus of 24 in. parabolic reflector. Beam spread in horizontal plane to about 80 deg. by diverging roundels.

E. Incandescent Airport Floodlight. Unit equipped with 14-3000-watt 32-volt incandescent lamps in the focal axis of a parabolic trough reflector The horizontal spread is 180 deg.

F. Airport Arc Floodlight. Unit equipped with a 150-ampere high intensity arc mechanism in the focus of a 21 element Fresnel lens. The horizontal spread is 180 deg. The 5-kw. or 10-kw. incandescent lamp may also be used with this unit.

G. Airport Arc Floodlight. Unit equipped with an 18-in. glass parabolic mirror and two front door glasses, one with clear glass and the other with 80 deg. spread lens. The spread lens may be swung back and the unit used as a high powered ceiling projector or as an auxiliary beacon. The lamp mechanism is automatic, operating at 55 amperes on a line voltage from 80 to 125 volts direct current

A beam of light has been found useful in determining the height of ceiling. The beam is directed on the clouds at a fixed angle and by sighting at the spot on the clouds from another point the height of ceiling is determined by triangulation.

Whereas the lighting facilities previously referred to follow rather definite regulations established by the Department of Commerce, a wider range of choice is

left to the engineer in selecting a system for the actual illumination of the field. The Department of Commerce requires for a field entitled to an "A" rating a minimum vertical illumination of not less than 0.15 foot-candles over the usable part of the field This is the illumination measured on a plane at right angles to the field surface and is a measure of the value of illumination incident upon the vertical sides of obstacles, grass, etc., facing the source of light. The light sources must be located so as to cause the least amount of glare in the eyes of the pilot for excessive glare is a potential cause of accidents. Needless to say, simplicity in operation and maintenance, together with reliability, are essential characteristics of the light sources. The system employing light sources close to the ground has met with general favor and may be divided into two divisions; *viz.*, the centralized system and the distributed system. In the former system a single large light source or a group of smaller light sources concentrated at one point is employed for obtaining the field illumination; in the latter, a number of relatively smaller units placed at two or more locations around the landing area are employed. The equipment (Fig. 9) used for field illumination employs both arc and incandescent light sources and a variety of optical systems for obtaining a fan distribution of light. In all cases, the vertical spread of the beam is restricted to a few degrees and the horizontal spread expanded to 45 deg. to 180 deg.

It is interesting to note a trend toward the study of the character of the field surface with respect to night illumination. Obviously, the higher the coefficient of reflection of the surface, the greater the amount of light reaching the observer's eye. Just as our highway executives have found it desirable to mark road boundaries and obstacles with white paint to make them conspicuous at night, so our airport engineers and managers will find the judicious use of light surfaces and white paint will greatly assist in the discrimination of essential objectives at night.

Abridgment of

The Fabrication of Large Rotating Machinery

BY H. V. PUTMAN[1]

Associate, A. I. E. E.

Synopsis.—*This paper is not intended as a general treatment of the above subject. It presents some of the more interesting experiences of the company with which the author is connected, in changing its designs of rotating machinery to employ fabricated steel in place of castings.*

* * * * *

WHAT are the advantages of fabricated steel that have led to its adoption in place of castings by some of the largest electrical manufacturing companies? It is not entirely a matter of cost, for while fabricated structures are usually cheaper, many show but little saving, and small structures of high activity are actually cheaper cast.

Even at the same cost, however, the use of fabricated steel may be justified for the following reasons:

1. The possibilities of future cost reduction are greater because the fabrication of steel is a comparatively new art, while the cost reduction possibilities of the cast construction have been largely exploited through many years of manufacturing experience and development.

2. The elimination of patterns is a clear gain. This is of greatest value in large special machines where only a single unit is made. It applies also to large bedplates where there are few exact duplicates and where, with castings, continual pattern changing was necessary.

3. The fabricated steel design is flexible. A large number of different structures can be made from a limited number of parts by welding them together in different combinations. Minor changes are easily made; greater strength may be obtained when required by additional structural members.

4. Shorter deliveries are possible because, with the foundry and pattern problem eliminated, the whole manufacturing process can be done in one shop, thus permitting greater concentration of responsibility in the manufacturing organization, a most important factor contributing to short deliveries.

5. The saving in weight is a valuable feature—especially in turbine generators and in all machinery used on shipboard. Some of the largest turbine generators can now be shipped with armature coils and laminations completely assembled. This not only eliminates the necessity of assembling coils and laminations in the customer's plant, but makes it possible to test these large machines for losses before shipment.

6. Fabricated steel structures are often better than those which were cast. There are many sales

1. Section Engineer, Synchronous Motor Section, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Presented at the Regional Meeting of the Middle Eastern District of the A. I. E. E., March 20-22, 1929. Complete copies upon request.

arguments in their favor and they are being demanded more and more by the trade.

Most of these points were listed in the beginning as economic advantages of fabricated steel before the decision to adopt it was made. Already the truth of

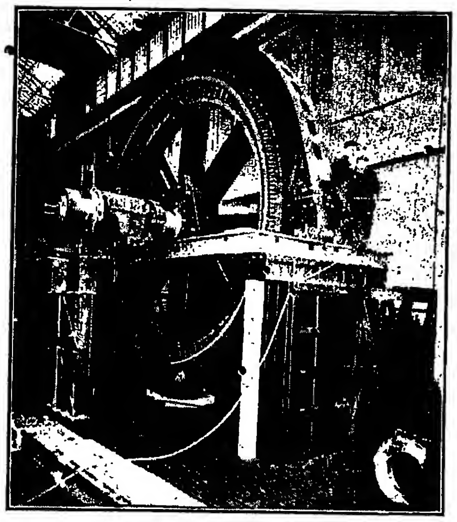


Fig. 1—5000-Hp., 82-Rev. Per Min. Synchronous Motor for Steel Mill Drive Assembled for Test

these statements is being demonstrated. New machines, comparable with the best machine tools, are being built to facilitate the practical application of the arc welding and gas cutting arts to quantity production.

The possibility of short deliveries was recently demonstrated in connection with an order for two

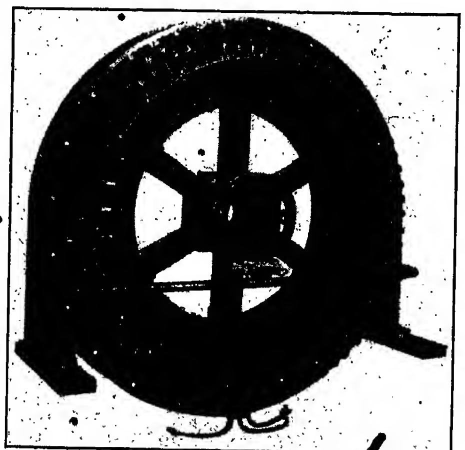


Fig. 2—Typical Low-Speed Synchronous Motor Stator with Fabricated Rotor in Place

5000-hp., 82-rev. per min. horizontal synchronous motors for steel mill drive, the first of which was delivered in ninety days and the second ten days later.

Fig. 1 shows a picture of the first machine, just 82 days after receipt of customer's order, when it was turned over to the Test Department for complete engineering tests. These motors are among the largest in physical dimensions ever built for an industrial drive. The fabricated steel construction, together with a completely equipped fabrication shop, made this extremely short delivery possible.

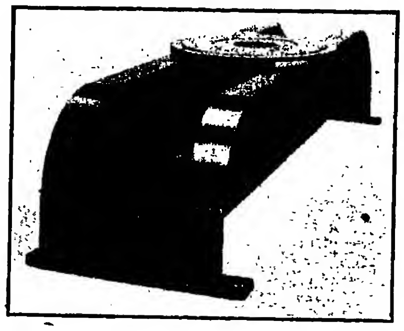


Fig. 5—Typical Fabricated Upper Bracket for Vertical Waterwheel Generators

Some of the special problems encountered by the Engineering Department in redesigning the various lines of rotating machines are of interest. One problem was to get designers to think clearly and with an open and unpredjudiced mind about the fundamental design problems of fabricated steel. Incidentally, much new thinking was done about the old designs in cast iron, and it was discovered that cast structures were designed as they were—not because of the requirements of the structure or the machine, but because of the requirements of foundry practise or the machine tools. Such a conclusion seemed so obvious as to be almost axiomatic, but a consideration of it helped to establish a new basis of thinking for the new design work in fabricated steel.

It was determined that all knowledge of cast design

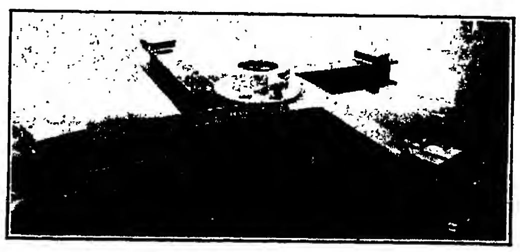


Fig. 6—Typical Lower Bracket for Vertical Water-Wheel Generator

should be put aside and even the appearance forgotten in an effort to make new designs with open, unbiased minds. The requirements of each machine or structure were determined; then a study made of the structural materials, plates, bars and beams, to see how these materials could be best employed to meet these requirements.

There had to be a definite reason for each step taken in the design work. As a result, the new designs were found to be radically different from previous cast structures and usually, much simpler in construction. Any savings were found to depend on the simplicity of the design and its general suitability to the use of structural materials.

The design of the different lines of fabricated

Fig. 7—Typical Vertical Waterwheel Generator, 625-Kv-a., 2400-Volt, Three-Phase, 60-Cycle 200-Rev. Per Min.

machines is now completed and it is interesting to see how this point of view has been followed out in different lines.

The frame construction of the smaller synchronous motors and generators having the core stacked on bolts between two frame rings gas cut from steel plate and

Fig. 8—9500-Kv-a., Turbo Generator Showing Fabricated Frame Construction

left open in the back is now well known. It is a radical departure from the old cast frames in appearance but it is adapted to the use of structural materials and it fulfills all the requirements of the electrical machine even better than did the cast construction. Fig. 2 shows a typical synchronous motor having this frame construction.

In the waterwheel generators, the upper and lower brackets are of especial interest because of their radical departure from similar cast structures and their suitability to structural materials. Figs. 5 and 6 show these brackets and Fig. 7 a complete vertical machine.

Another excellent example is the frame construction of the new line of 3600-rev. per min. turbine generators shown in Figs. 8 and 9. This frame is built up of plates spaced periodically along the core. These plates support the frame bolts on which the punchings are stacked and at the same time provide the necessary air passages re-entrant ventilating system. Except for drilling the end plates which receive the punching bolts the whole structure is produced by the torch arc welder, and the bending rolls and presses in the structural shop.

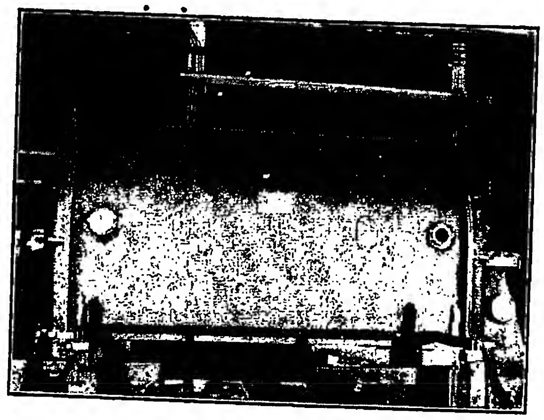


Fig. 9—9500-Kv-a. Turbo Generator Assembled for Test

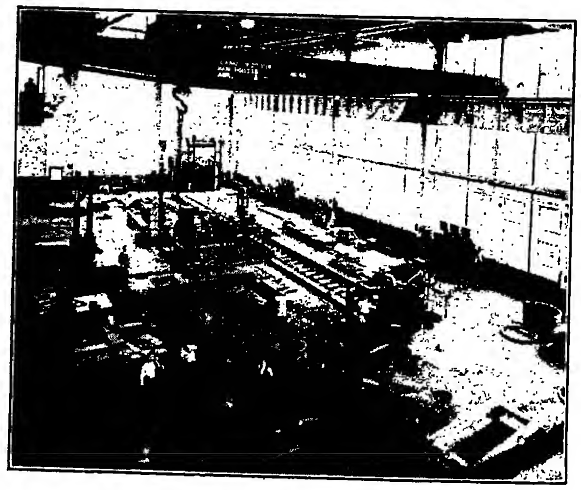


Fig. 11—General View of New Fabrication Shop

A plate on the back serves as a cover to the air passages and extends over the armature winding on each end where it meets the pressed steel end bells that are bolted to it. This structure is peculiar, in that while it is especially adapted to the fabricated steel construction, the completed machine can hardly be distinguished from the previous cast structures.

Another problem of the engineering department has been the "appearance problem." While some of the fabricated machines resemble closely their cast iron predecessors, many of them are radically different in appearance. It is a fact that what looks good to one

is simply a matter of what he is accustomed to. If one is accustomed to looking at cast machines, they look best, but as fabricated machines become more familiar they improve in appearance. What appears radical today seems commonplace tomorrow.

This was especially true in the case of fabricated H beam bedplates. Because of their appearance, they produced considerable unfavorable comment at first, and some customers actually refused to have them. But it is a fact that H beam bedplates are really better bases than cast bedplates. The U section of the cast bedplates, with its smoothly rounded corners, was not dictated by any requirement of the structure, but they were made that way so that the pattern could be pulled more easily from the sand. The idea of grouting bedplates into the top originated with the fabricated bedplate and when so grouted, its appearance is equally as good as that of the cast bedplate. It is just as natural to grout a fabricated bedplate into the top, as to set a cast base above the floor line. Architects are realizing this and are designing the floors of power houses and motor rooms with recesses to receive the bedplates, so that after the grouting is done, the floor covering can be placed flush with the top of the bedplates. And today, no one hears a word of criticism regarding the appearance of fabricated bedplates, and very little indeed, regarding the appearance of fabricated machines.

Round corners and sweeping curves are descriptive of cast structures and cast machines. Flat surfaces, square corners, and abrupt lines are equally descriptive of fabricated machines. It is only a matter of time when they will appear equally attractive; in fact, the straight line and the square corner have already come into prominence in the design of modernistic furniture, lighting fixtures, and decorations.

The major problem of the manufacturing department was the construction of a new fabrication shop. Fig. 11 gives a general view of the shop. The largest piece of equipment is a vertical bending roll for rolling into circles the frames of d-c. machines and the spider rims of a-c. machines. There is also a 1000-ton crimping press for putting an initial bend in the ends of the slabs to facilitate starting them in the rolls. A large furnace which will take slabs 37 ft. long is provided for heating the slabs preliminary to rolling, and also for annealing completed structures. An approach table is provided for carrying the slabs from the furnace to the crimper and the bending rolls. The furnace, approach table, crimper and bending rolls are all controlled from a single pulpit located near the rolling mill.

Other pieces of equipment include a flange press for forming the pressed steel end bells for turbine generators and a short blast room capable of receiving the largest completed fabricated structures. Here, all fabricated structures are shot ballasted before going to the assembly section. Every bit of rust and scale is removed so that when paint is applied to the surface there is no danger of its chipping or scaling off, because it has been applied to a surface 100 per cent clean.

MORE EFFICIENT HYDRO PLANTS

One of the most interesting features in the work of hydro-electric development has been the persistent endeavor to utilize to the fullest extent the potentially available energy of the water flow. Performances of mechanical equipment have been so consistently improved that for a given head and volume not only are the water-wheels designed for that service of remarkably high efficiencies but the products of different manufacturers come exceedingly close to duplicating results.

There has, comparatively recently, been a notable increase in the movement to utilize full stream flow by a series of generating stations located along the river course. The development of the Catawba River in the Carolinas by the Duke Power Company is representative of this "chain" planning, Oxford station being operated, to all intents and purposes, from the tailrace of the Rhodiss station and discharging into the pond of the Lookout Shoals station. The Chippewa Falls plant of the Northern States Power Company of Wisconsin follows a similar trend, being operated with the Wissota development, two miles upstream, in connection with storage reservoirs. Seasonal variations have, however, led to a further development at Chippewa.

By providing six comparatively small units at the Chippewa Falls plant it is possible to load the various machines to the point of maximum efficiency. In order that this efficiency may be maintained under varying conditions of operation, the propeller-type machines have been provided with movable blades whose pitch may be changed to give maximum efficiency for any gate opening or maximum output for any variation of head. This is a most interesting phase of hydraulic power development and should, if proved in service, be important in the future design of low-head plants. Steam stations have no monopoly of the economical features of good generating practices.—*Electrical World.*

LIGHT UP HOUSE NUMBERS ABROAD

Stockholm homes are to have illuminated street numbers this year, according to a report from the Swedish capital. Electrical experts have been asked to draw up plans for the necessary wiring, and the municipal authorities are expected to act upon them in the near future. The Stockholm Rent Payer's Association has gone on record as being highly in favor of the project.

Compulsory illumination of house numbers has been suggested in Stockholm before, but it was not until city doctors and cabmen began complaining of the difficulty of finding the right house number after dark that a vigorous campaign for lighted numbers was begun.—*Transactions, I. E. S.*

Electrical Features of the Kansas City New Water Works

BY ALBERT L. MAILLARD[1]
Member, A. I. E. E.

Synopsis.—This paper describes the main electrical features of the new works recently constructed for additional water supply for Kansas City, Missouri. It enumerates the chief features of the power contract under which the city is purchasing its power. It states the type and capacities of the major electrical equipment and touches briefly on the wiring and lighting systems. It does not treat the efficiencies or the costs of the equipment.

* * * * *

UNTIL comparatively recently standard water-works practise was confined almost exclusively to the plunger type of pumps driven by reciprocating engines. They afforded economic operation over a wide range of conditions, but the floor space requirements and the capital investment were considerable. When it became expedient, in many cases, to install additional pumping capacity in a limited space and with limited funds, the turbo centrifugal pump received recognition. Its successful performance paved the way for electric motor centrifugal pumps which offered still further economies in capital investment. At the time when Kansas City was formulating its decision on the important question of steam-turbine or electric motor centrifugal pumps, standard practise, especially in the case of high-head pumpage, was strongly in favor of the former. In fact, of the thirty-five largest cities of the United States, only two or three used the electric motor as a prime mover, and one of these operated on "off-peak" power using storage reservoirs. Inasmuch as Kansas City is on a direct pumpage basis and cannot avail itself of the benefits of "off-peak" power rates, conditions are not exactly comparable.

Another factor which militated against electric drive in Kansas City was the fact that the city would be totally dependent, for its water, on purchased electric power with all the hazards, real and imaginary, that are involved in seven or eight miles of feeder lines, in addition to other likely causes of service interruptions. In consequence, the electrical layout had to be such as to give maximum assurance of continuity of service but still be kept within limited capital investment since the latter was one of the chief assets of electric drive. Inasmuch as a comparison of over-all costs, that is, fixed and operating charges, between steam and electric drive was made, it was necessary to have low power rates to offset increases in fixed charges.

POWER CONTRACT

At this stage it might be interesting to discuss the power contract between the city and the local public utility which contains some unusual features and which had some bearing on the selection of the type of equipment chosen. Some of the outstanding features of the contract are these:

1. That the city shall have first call on the power plants of the company.
2. That no substations shall intervene between the pumping stations and the power plant.
3. That duplicate feeders of very liberal capacity shall connect the stations with the power plant by two separate and independent routes.
4. That no other consumers shall be served by these feeders.
5. That the "off-peak" demands be calculated on a monthly average of daily half-hour peaks rather than on an individual half-hour.
6. That peak demands due to large fires, or emergency due to breakage of large mains, etc., not be considered in establishing the maximum demand.
7. That the peak months of water pumpage—viz.—June, July and August, not be considered in establishing the maximum demand but be treated as individual months.
8. That a credit or debit be allowed or charged depending on the cost of fuel relative to a certain base price.
9. That a reduction in the demand charge be made based on 80 per cent power factor. Maintenance of 100 per cent power factor reduces the demand charge by 20 per cent.

The following are the rates:

Demand Charge:

$1.56¼ per month per kw., plus $3000.00 per month to cover charges on feeder lines.

Energy Charge:

$0.007 per kw-hr. until the demand at the high-lift station exceeds 2800 kw.
$0.00675 per kw-hr. until the demand at the high-lift station exceeds 4250 kw.
$0.0065 per kw-hr. until the demand at the high-lift station exceeds 5600 kw.
$0.00625 thereafter.

The life of the contract is twenty years but it may be terminated upon the giving of due notice by the city should the company fail to give first-class service.

1. Consulting Engineer, Kansas City, Missouri.

Presented at the Regional Meeting of the South West District No. 7, of the A. I. E. E., Dallas, Texas, May 7-9, 1929. Printed complete herein.

Choice of Motor Equipment

At the low-lift stations the range of head was very wide and since better pump efficiencies could be obtained with a change in speed, the two winding motors received considerable thought. A more careful examination of the head fluctuations disclosed the fact that the extremes in head variation occurred during only 20 per cent of the time. Based on the narrower limits of head variation, it was decided to use synchronous rather than two-winding induction motors. The former had the advantage of better efficiencies during 80 per cent of the time, better power factor at all times, less operating complications and slightly less cost; while the latter afforded better pump efficiencies for 20 per cent of the time. Besides, synchronous motors would raise the power factor made low by the many small induction motors in the purification works. The power factor clause in the power contract was a determining factor in the decision.

Accordingly, unity-power-factor, synchronous motors were selected for the low head stations and 0.8 power factor (leading) motors for the high head station.

Outdoor Substation Equipment

Power for the low-head stations is bought from the Kansas City Power & Light Company at 13,200 volts and is transformed to 2300 volts in an outdoor substation which is the property of the city. Two feeders, one overhead and the other underground, serve the station by two separate routes. The substation equipment comprises two 2500-kv-a. banks of transformers connected delta-delta. Each transformer is rated 833 kv-a., 13,200/2300 volts, single-phase, 60-cycle. These capacities were chosen on the basis that when overloaded 25 per cent one bank would carry 90 per cent of the ultimate load. Transformers are equipped with oil conservators and thermometers.

The two incoming feeders form a loop and are protected by directional relays. The overhead line is provided with a hairpin loop and oxide film arrester. Each bank of transformers is controlled by an oil circuit breaker on the high-tension as well as on the low-tension side and is differentially protected. A tie-line breaker on the high-tension side provides flexibility while the low-tension side is connected to a bus which is sectionalized by disconnecting switches. From this bus four feeders, two to each station, supply the low and secondary station. Each station is fed from both sections of the bus.

The oil circuit breaker equipment comprises three 400-ampere, 25,000-volt and two 1200-ampere, 15,000-volt breakers, the latter of which are enclosed in switch houses. All breakers are hand operated with d-c. automatic trips. The direct current is furnished by a portable battery located in a meter house and connected to a battery charger.

At this station the power is metered on the high-tension side. Duplicate sets of metering transformers, one for the company and the other for the city, are installed on the structure. Duplicate sets of meters are located on the switchboard in the secondary pumping station. The metering equipment consists of recording demand and power-factor meters and integrating watthour meters.

Low-Lift Station

Water is pumped from the Missouri River to the purification works, about 2000 ft. away. The pumping station in which this initial pumping is done is known as the Low Lift Station. Each of the four main pumps in this station is driven by a 400-hp., unity power factor, synchronous motor operating at 2300 volts, three-phase, 60-cycle, 360-rev. per min. The excitation for these motors is supplied by two 30-kw. motor-generator sets. Each set is capable of furnishing excitation for five 400-hp. motors. These sets may be used for lighting in case of failure of the lighting transformer.

The control for this equipment comprises a fourteen-panel switchboard on a gallery floor 28 ft. above the pump room floor. A mechanical remote-control system through bell cranks and pull rods operates the oil circuit breakers which are supported on a pipe framework and are located on another gallery 12 ft. below the switchboard floor.

The main bus is sectionalized by two oil circuit breakers. In the section between these breakers there is connected a station service feeder which serves power, lighting, and heating transformers. Each outside section of the bus is fed by an incoming feeder, each feeder having the capacity of the entire station. One section serves two motors, while the other serves the remaining two motors and the future unit.

Motor starting is accomplished by means of compensators and a starting bus. This bus is sectionalized by disconnecting switches, each section being served by a compensator. Each compensator is of sufficient capacity to permit of four starting operations within 10 min. without excessive heating of the compensator. In this station there are eleven 600-ampere and four 400-ampere, 7500-volt oil circuit breakers.

Auxiliary power for operating vacuum pumps, sump pumps, motor-generator sets, crane and gate valves in this building as well as the revolving screens in the intake building is obtained from three 25-kv-a., 2300/230-volt transformers connected delta-delta. The lighting transformer is rated at 15 kv-a., 2300/230/115 volts.

Both the intake building and the low-lift station are heated electrically and are served by a 150-kv-a., three-phase, 2300/230-volt transformer. Industrial oven type, 220-volt ribbon element heaters suitably mounted and backed with reflecting and insulating material and provided with grill work in the front are placed along the gallery in a manner similar to steam radiator practise. In most locations two elements are used to form

one radiator but they are individually controlled by local switches so that flexibility in controlling the heat may be obtained. All the transformers in this station are controlled by one oil circuit breaker but are protected by individual S & C fused disconnecting switches.

Secondary-Lift Pumping Station

After the water has been purified it is pumped to reservoirs at the high-head stations. This being the second stage of pumping gives to the station the name of secondary lift pumping station. The pumping capacity of this station is the same as that of the low-lift station and since the heads are about equal, the electrical equipment is a duplication of that at the low-lift station. In addition to the main pumping units and the vacuum pump motors there are three 75-hp., 2300-volt, 1800-rev. per min. motors driving wash water pumps, two 60-hp., 2300-volt, 1800-rev. per min., and two 25-hp., 220-volt, 1800-rev. per min. motors driving house service pumps. The 75-hp. motors are controlled by automatic "across-the-line" contactors and push buttons. Each motor may be controlled from any one of three points. The 60-hp. motors are started across the line by closing the oil circuit breaker. The 25-hp. motors are controlled by starting compensators.

In addition to these pump motors all the power used in the chemical house, chlorine house, filter house, Dorr clarifiers, and the lighting for all these buildings and the grounds are controlled from the switchboard in the secondary-lift station. In the chemical house there are about 150 hp. in motors ranging in size from ¼- to 50-hp. Four 7½-hp. motors operate the Dorr clarifier mechanisms.

The switchboard comprises 21 panels and the system is that of mechanical remote-control, with the main oil circuit breakers and bus located on the lower floor in a switch-room beneath the switchboard. The starting bus, its compensators, and oil circuit breakers are located at the back of the switchboard. The busses are sectionalized in a manner similar to those at the low-lift station, but between the sectionalizing breakers there are two feeders, one for power and one for light. This building is not electrically heated. In the chemist's laboratory, however, there are ovens, sterilizers, refrigerators, distillers, etc. Another small difference between this station and the low-lift station is that the field rheostats for the main motors are electrically controlled in this station. The 36-in. discharge valves in both stations are electrically operated.

There are seventeen 600-ampere and four 400-ampere, 7500-volt oil circuit breakers in this station.

The auxiliary power transformers comprise three 75-kv-a., 2300/230-volt units connected delta-delta. Multiple lighting is served by a 75-kv-a., 2300/230/115-volt transformer, and series lighting by an 8-kv-a. constant-current transformer.

Lighting and Wiring

Lighting in almost all the buildings is laid out to give at the working plane an intensity of six foot-candles exclusive of a liberal allowance for dust and aging of the lighting units. In the filter galleries, this intensity is maintained but over the filters and in the pipe galleries a lower intensity is used. A generous number of wall receptacles is installed. Glass and fancy fixtures are omitted, porcelain enameled steel reflectors being used instead. The installation is substantial and put up to stay for many years. Galvanized iron conduit and condulets are used throughout. Wire is 30 per cent para, double braided, except in damp places where triple braided weatherproof wire is used. Waterproof fixtures are used in such places.

Around the uncovered basins flood lighting projectors, standing two feet above the ground, are used. This is done to reduce the number of bugs which swarm around lights, die, and fall in the water. At each flood light location there are three waterproof condulets, one for connecting the projector, another housing a switch for controlling the projector, and the third, a receptacle. The receptacle permits the concentration of more than one projector at a location during periods of cleaning of the basin. The projectors are fed by armored cable laid from 12 to 18 in. in the ground. At various manholes, lights, switches and receptacles are located and connected to the same cable system. About other parts of the purification works, there are distributed lighting standards for general illumination. Along the roads leading to the pumping station there are similar standards. They are all connected to a series system which is served by a constant current transformer in the secondary-lift station and operated at 6.6 amperes.

Power Cables

All power cables are insulated with varnished cambric and are lead covered where they are installed in pump-room floors or other places that are likely to be damp or flooded with water. Standard 5000-volt insulation is used on 2300-volt circuits and 17,000-volt insulation on 13,200-volt circuits. On 2300-volt circuits 7500-volt potheads are used. The control wiring for the East Bottoms Station is lead covered.

Underground Cable System

Between the outdoor substation and the low- and secondary-lift pumping stations as well as between the secondary station and the chlorine and chemical houses the feeders are three conductor, varnished cambric insulated, lead covered cables installed in fiber ducts surrounded by a concrete envelope. Cables vary in size from No. 6 A. W. G. to 800,000 circular mils. Conduits vary from four to ten ducts. Concrete manholes, properly drained, are installed at frequent intervals.

East Bottoms Stations

The new electrically operated high-head station is

known as the East Bottoms Station and is located about five miles from the purification works. The present main motor equipment consists of two 2000-hp., 0.80 power-factor (leading) 13,200-volt, three-phase, 720-rev. per min. motors equipped with direct-connected exciters. They are provided with temperature detectors and enclosing bell ends. The station is planned for six such motors.

The switchboard comprises 14 panels at present but will ultimately be expanded to 21. The system is that of electrical remote control, some operations being performed by manually operating the control switches while others are automatically controlled by relays and interlocks. The front of the switchboard faces the pump room, while access to the back is had from the switch house. All busses and switching equipment, oil circuit breakers, instrument transformers, compensators, etc., are enclosed in a monolithic concrete cell structure.

The station is fed by two 13,200-volt lines direct from the public utility's power-house bus. Ultimately there will be four such feeders. The main bus in the station is in duplicate but may be made a continuous bus by use of a tie breaker at one end of the bus structure. Indicator lights are located over the disconnecting switch compartments of the cell structure to show the position of the controlling oil circuit breaker.

The oil circuit breaker equipment comprises one 600-ampere, and seven 400-ampere, 15,000-volt units each rated at 14,000 r. m. s. amperes at 15,000 volts, and four 400-ampere, 15,000-volt units each rated at 1500 r. m. s. amperes at 1500 volts. All but two breakers are of the phase per cell type. The breakers are all solenoid operated and the control current is supplied by a storage battery. A small motor-generator set furnishes the trickle charge for the battery.

Motor starting is accomplished by compensator and starting bus as in the other stations but in addition neutral breakers provide a smoother transition from starting to running voltage. Motors have 85 per cent pull-in torque and full voltage is applied before the field circuit is closed.

At this point, the sequence of operations in starting a motor might be interesting. First, the neutral breaker is closed by closing its control switch, which operation automatically closes the compensator breaker. Next, the starting breaker control switch is closed. An accelerating relay controls the next steps. As it closes, it trips the neutral breaker which in turn closes the running breaker. The field breaker control switch is then closed and the compensator breaker control switch, which is the same as the neutral breaker control switch, is opened, which automatically trips the starting breaker. If the field breaker be not closed within ten seconds after closure of the running breaker, the field failure relay trips the running breaker. This time limit has been set on account of hydraulic conditions.

With the closure of the running breaker, a solenoid valve on the automatic check valve is closed. This will be described more fully later. Due to the fact that this solenoid valve closes only after the running breaker is closed, the motor "pulls in" against a closed discharge because the check valve cannot open while the solenoid valve is open. This reduces the required pull-in torque of the motor.

In this station there is a 30-kw. motor generator set which is capable of performing four important functions. It can supply excitation for any one or two of the main motors. It provides a source of direct current for lighting; it can give a full charge to the battery; it provides current for the control circuit while the battery is out of service or being charged.

Auxiliaries are fed from a bank of three 25-kv-a., 13,200/230-volt transformers. Lighting is supplied by a 25-kv-a., 13,200/230/115-volt transformer. Emergency lights are fed from the battery and go on automatically whenever the lighting transformer is out of service.

The description of this station would be incomplete without a word about the automatic stop and check valve. It opens and closes automatically with unbalance of hydraulic conditions in the valve. The necessary unbalance of hydraulic conditions may be controlled by a solenoid-operated valve in the blow-off line of the main valve. The solenoid circuit is interlocked with the running breaker and a control switch on the switchboard is inserted in the circuit. With the closing of the running breaker the solenoid valve closes and permits the main valve to open as soon as the pressure on the pump side of the valve becomes greater than that on the line side. As soon as the running breaker trips out, the solenoid valve opens and the main valve closes. The control switch on the board permits the operator to open the solenoid valve circuit, thereby opening the solenoid valve, which in turn closes the main valve even with the pump operating at normal speed. The operation of the main valve may be noted by the pressure-gage reading. This permits of the checking of one of the most important automatic features of the station without disturbing normal operation.

The use of 13,200-volt motors and electric radiators for building heating are radical steps in waterworks practise. It must be realized that the city is entirely dependent upon electrical power for its water. Moreover, this electric power is being purchased from the local public utility. It is a great tribute to the reliability of electric public utility service and to the electrical industry as a whole.

By a decisive vote, the citizens of Sioux Falls, South Dakota, refused to issue $100,000 in bonds for the enlargement of the municipal power plant. This is considered to be a victory for the Northern States Power Company which operates in Sioux Falls.

Fused Arcing Horns and Grading Rings

Design, Construction, and Operating Experience on 66,000-Volt Transmission Lines of the Union Gas & Electric Company

BY PHILIP STEWART[1]

Associate, A. I. E. E.

Synopsis.—This paper considers the use of fuses on insulator strings of high-voltage overhead conductors, to interrupt the arc at times of flashover before the line relays operate to disconnect the circuit. Consideration is first given to the original development of this idea, in which a fuse was connected between the line conductor and an arcing ring, attached to the second insulator unit. When an excessive voltage occurs on the conductor to ground, there is a flash between a two-pronged horn on the top insulator unit and the ring. The circuit is completed through the fuse, which immediately opens, breaking the arc. Further consideration is given to a later development of the principle, in which two expulsion type fuses replace the two-pronged horn at the top of the insulator string and the arcing ring is placed at the conductor end of the string. Data are presented from tests and from experience on about 100 mi. of 66,000-volt circuit, of the Union Gas and Electric Company, Cincinnati, Ohio.

Introduction

The general practise up to this time is to isolate faults at the ends of feeders or transmission circuits in trouble. This is done by means of oil circuit breakers actuated by relays. Lines and circuits so equipped immediately go out of service in case of faults. The fused insulator string is a device for isolating faults right at the point where the fault occurs, interrupting fault current only, and not interrupting the useful service of the line or circuit.

It is now generally considered good practise to provide some arrangement of arcing or grading rings or horns, at all insulator strings of important high-voltage transmission circuits. Experience and tests point to this means of preventing cascading and possible shattering of insulators by flashovers caused by transient voltages on the line conductors to ground. The use of such devices reduce the time the line may be out of service, due to flashed insulators. The development of the fused device for insulator strings is an attempt to further reduce the interruptions, especially those of short duration caused by the line switch opening to clear the surge flashover and subsequent short circuit which may last for only a few seconds.

One of the two generating plants in the Cincinnati territory is located at Columbia Park, on the Ohio River, about 20 mi. west of Cincinnati. This plant is operated as a base load station at as nearly full load as possible at all times. The major part of the load from Columbia to Cincinnati is carried over four 66,000-volt transmission circuits carried on two double circuit tower lines. These circuits are connected to Terminal Switching Station, north of Cincinnati. From Terminal Station, two 66,000-volt circuits connect to each of three major distribution substations. Two circuits also connect to the system of the Dayton Power and Light Company.

It is very important for the operation of the entire system that these circuits be kept in service without interruptions. It is especially so on the circuits from Columbia to Terminal Station. When these lines were built, the insulator strings were equipped with flux controls. Six insulator units were used in each string. The first year's operation was good, but the disastrous results of insulator flashovers and line outages were evident.

Original Development

The first arrangement using fused arcing rings consisted of a string of seven insulator units and was provided with two horns at the top and a split oval ring below the fifth unit. Fuse clamps were mounted on the ring and conductor clamp, thus shunting the two lowest insulators with a fuse. With the fuse in, the line is insulated with five units between the line and ground. After the fuse has been blown, the insulator will consist of seven units. In this way the flashover distance will be increased and it was thought that in case a second surge originated near this point before the fuse was renewed, the flashover would occur at the next adjacent point of support.

Tests were made with this arrangement to observe the performance in clearing flashovers on the 66,000-volt system. All 66,000-volt lines were energized into Terminal. The tests were made on a line from the main bus. The insulator string was shunted by a piece of small copper wire in order to start the flashover. The line was closed in on the shorted insulator by means of the station oil circuit breaker. An oscillograph was used in order to obtain the short-circuit currents and voltages. An average short-circuit current of 2970 r. m. s. amperes was obtained, with 9000 volts, phase to neutral, during short circuit. The 10-ampere 37,000-volt carbon tetrachloride fuses cleared in one cycle, in each case clearing before the relays operated to open the oil circuit breaker.

Tests were made in the high-voltage laboratory of the General Electric Company. In these tests it was established that a power arc can be produced by fusing

1. Union Gas & Electric Company, Cincinnati, Ohio.

Presented at the Regional Meeting of the Middle Eastern District of the A. I. E. E., Cincinnati, Ohio, March 20-22, 1929. Printed complete herein.

a fine copper wire connected between the arcing rings of an insulator string. This method of starting an arc was used throughout.

Tests were also made to investigate the performance of the fused rings when subjected to artificial lightning; first with a ring made of 1½-in. pipe, then a strap iron ring, and in the third case the horns were supplied with hemispheres. These three tests gave approximately the same flashover voltages and arcing characteristics, thereby indicating that for this short string, grading is not so necessary. The average flashover voltage determined in these tests was 530 kv. maximum, which is the same as the flashover voltage between needle points placed the same distance apart. This indicates that the voltage distribution on the comparatively short string of insulator units does not affect the flashover of the parallel gap. However, on longer strings, grading is necessary, and the multi-gap effect of the units must be overcome.

Further tests determined the effect of artificial lightning discharge on the fuse alone. Ten discharges of approximately 6000 amperes (maximum) had no apparent effect upon the fuse, due to the exceedingly short time during which the current was flowing. This shows that the fuse is probably blown by the follow-up current and not by initial current due to the lightning discharge.

Operating Experience

In the spring of 1927, fused arcing rings were installed on two of the Columbia—Terminal circuits, and four of the shorter lines, leaving Terminal, totaling approximately 65 mi. of circuit so equipped. During an eight month period succeeding this installation, there were six cases of the fuses blowing and clearing without

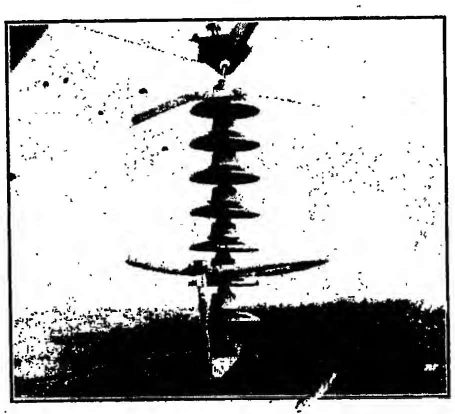


Fig. 1—Original Development of Fused Arcing Ring Using Carbon Tetrachloride Fuses

an interruption to service. There were three cases in which the fuses failed to clear and the circuit breaker opened, interrupting service on the line. During this period, ten fuses were blown. The three service interruptions were caused by the destruction of the fuses at the flashover points.

It is noted that the fuses functioned properly 77 per cent of the time and succeeded in preventing service interruptions 67 per cent of the time.

All failures of the device were due to failures of the fuse itself, caused by follow-up surge voltages. One case noted during the preliminary tests probably explains these failures. A blown fuse was inserted and an impact of very high voltage was applied. The arc followed a path from the conductor over the metallic part of the fuse within the glass tube, puncturing the glass, and passing over the outside to the ring and to the horn and ground. In actual practise, a dynamic arc would follow this first arc, causing destruction of the fuse.

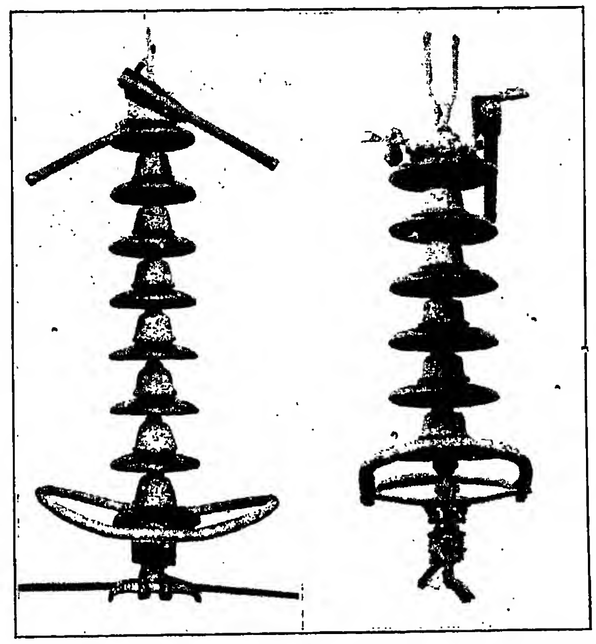


Fig. 2—Later Development of Fused Insulator String Using Expulsion Type Fuses as Arcing Horns

Development Using Expulsion Type Fuse

The operation of the fused arcing rings, using carbon tetrachloride fuses, (Fig. 1) was successful in preventing a number of service interruptions on the two Columbia—Terminal circuits on which they were installed. In considering the installation on the two remaining circuits, a more economical arrangement of the device was desired. First, the added cost for the extra insulator units shunted by the fuses did not seem to be justified by the first year's operation. Second, the carbon tetrachloride fuses were more expensive than expulsion type fuses. Therefore, the next development was an arrangement using two expulsion type fuses in place of the horn at the top of the insulator string, (Fig. 2) and a ring at the conductor end.

Tests were made on various makes of expulsion type fuses, some the standard products of different manufacturers and some specially designed by the Union

Gas and Electric Company. These tests were made at Terminal Station with the system set-up similar to that of the previous tests. In each case the fuse operated correctly to break the short circuit. The time required with a few exceptions was one-half cycle or less.

Further tests to determine the conductivity of the fuses after they had been blown established that there was practically no conducting material deposited in the fuse holder.

The diameter of the ring and the position of the fused horns were determined from tests made with the impulse generator of the General Electric Company so that flashovers on the assembled string occur from the end of the fuse to the ring without cascading.

In addition to more economical construction, the present assembly has an advantage over the original in that two fuses are employed. It was established by tests that both fuses will not blow at the same time, but one will remain in good condition. When one fuse is blown the arcing distance on that side is greater than on the side of the good fuse and second flashovers go to the tip of the good fuse. Therefore, the device will function for two consecutive surges originating on the same section of line before replacement of the fuses is necessary.

OPERATING RECORD WITH FUSED ARCING HORNS

Line	Year	Inter-ruptions	Flashed units	Type of fuse	Inter-ruptions prevented	Fuses blown
1761	1926	3	30	none		
	1927	2	6	S. & C.	4	9
	1928	0	0	S. & C	1	1
1762	1926	4	14	none		
	1927	1	2	S. & C.	2	4
	1928	0	0	S. & C.	1	1
1763	1926	1	0	none		
	1927	4	18	none		
	1928	0	0	Expulsion	1	1
1764	1926	2	6	none		
	1927	3	24	none		
	1928	0	0	Expulsion	1	1
1261	1926	1	0	none		
	1927	0	0	S. & C.	0	0
	1928	1*	0	S. & C.	*	2
1262	1926	3	6	none		
	1927	0	0	S & C.	0	0
	1928	1*	6	S. & C.	*	1
861	1926	0	0	none		
	1927	0	0	S. & C.	0	0
	1928	0	0	S. & C.	2	3
862	1926	0	0	none		
	1927	0	0	S. & C.	0	0
	1928	2	0	S. & C.	0	3

*Flashover at substation.

Upon operation, a bright metal clamp at the out end of the fuse is blown off and the condition of the fuses can be determined by patrolmen's visual inspection from the ground.

Operation in 1928

In the early part of 1928, the fused horns and grading rings were installed on the two Columbia—Terminal circuits not previously equipped with fused arcing rings. During this year there were no interruptions to service on any of these four circuits. Although there were comparatively few lightning storms, four fuses were found blown, indicating that they had been effective in preventing service interruptions.

For two years operation, there have been seventeen cases of flashovers on lines equipped with fused horns or arcing rings. Of these cases twelve interruptions have been prevented. This is an elimination of 70 per cent of service interruptions.

The accompanying table shows the operation record for the 66,000-volt tower lines during three years of service.

Conclusions

1. Arcing rings are essential equipment on important high-voltage transmission lines. Without arcing rings, many insulators are flashed and shattered due to cascading of the string. Shattered insulators mean a line outage for several hours caused by an abnormal condition existing only a fraction of a second.

2. Fuses in the flashover circuit interrupt and prevent the flow of follow-up current. Since the fuses function in approximately one-half cycle and protective relays are ordinarily set to operate in not less than 35 to 45 cycles, the short circuit will be cleared before the oil circuit breaker operates.

3. The fuse is not blown by the current of the initial surge, but by the current of the dynamic arc.

4. The use of fused insulator strings on the high-voltage circuits of the Union Gas and Electric Company has been a large factor in a considerable improvement in service and operating records.

5. Tests and operating experience, as well as economic considerations, show several advantages of the assembly using fused horns at the support end of the string, over the original assembly using a fused ring at the conductor end.

6. The adoption of fused horns and grading rings for important high-voltage lines has proved to be another means by which service and operation may be improved.

CORRESPONDENCE

To the Editor:

I wish to direct attention to a change which should have been made in the paper *Field Tests of the Deion Circuit Breaker* published in the Journal for February 1929.

On page 104 of the February Journal the last sentence of the first paragraph should end as follows: "the main current-carrying contacts were apparently in a condition to carry normal rated current *without* excessive heating at the end of the Chicago tests."

Yours very truly,

B. G. Jamieson.

Abridgment of

Arc Welding of Steel Buildings and Bridges

BY FRANK P. McKIBBEN[1]
Non-member

Synopsis.—The paper treats of the important matters of the revision of building codes, the preparation of specifications for welded buildings, the accumulation of cost data, the training of designers, the qualification of welders and inspectors, and additional tests of welded joints, which are now receiving attention. Investigations made toward the definite betterment of present conditions are cited and in the appendix are given proposed specifications for the arc-welding of steel buildings, with regard to general application, definitions, quality of structural steel and welding electrodes, welding apparatus, workmanship, qualifications of welders, the proportioning of parts and the protection of steel.

* * * * *

THE art of welding structural steel by electricity is developing rapidly, and this year witnesses many applications of this process to the construction and reinforcement of bridges and buildings. The electric arc furnished designing engineers with a new tool which has been widely adopted not only in the fabricating of bridges and buildings, but also in many factories for welding parts of machinery and assembling structural steel sections as substitutes for castings.

That with proper supervision of design and workmanship, one can secure safe construction is evidenced by the existence of over 60 welded buildings, in which no failures have been recorded. For a new type of construction, this is truly a remarkable record, but, we must not forget that welded construction in its early stages has received far more experimentation and more careful supervision in execution than did concrete or riveted work at the corresponding stages of their development.

Among the most important matters now receiving attention are revision of building codes, preparation of specifications for welded buildings, accumulation of cost data, training of designers, the qualification of welders and inspectors, and additional tests of welded joints.

Many municipalities are not revising their building codes in order to bring them in closer harmony with recent improvements in building construction. Among the changes being considered by many cities are the increase from the 16,000-lb. to the 18,000-lb. basis for structural steel and the permission to erect-welded steel building frames. Over 40 municipalities have already made provisions for welding in their codes, and many others, such as New York, Pittsburgh, Chicago, and Philadelphia, have committees at work on code revision. It is appropriate and timely that these committees should give proper consideration to the use of welding, and adopt the unit stresses for use in steel building design recently decided upon by the American Welding Society in its building code, thus bringing nearer a uniform building code, so long desired by architects and structural engineers.

The elimination of noise is not the only desirable quality possessed by welding. Of equal value is the very considerable reduction in weight of steel effected in many cases. This latter feature was very well illustrated in the building at the General Electric Company's West Philadelphia plant, in which roof trusses were built without the use of a single rivet, thus eliminating over a thousand steel gusset plates each approximately 17 in. by 29 in. in size. Moreover, the absence of rivet holes in the tension members made less steel possible in these members. These and other

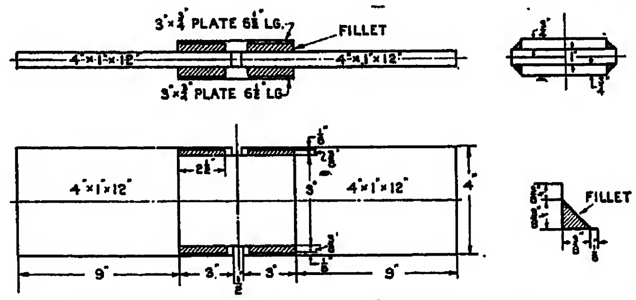


FIG. 1—TEST SPECIMENS FOR FILLET WELDS

savings resulting in reducing the weight of each of a series of roof trusses of 58-ft., 6-in. spans from 6800 lb. for a riveted truss to 5000 lb. for a welded truss carrying the same loads; and of 78-ft. trusses, from 13,200 lb. riveted to 9200 lb. welded. These are very considerable reductions in weight and should result in lower costs.

Much attention is being paid to the qualification of welders for structural steel welding, and the tendency is to exaggerate the importance of this matter. Good welders are wanted and they can be secured by testing applicants with some welding which, though reasonably simple, is sufficiently searching to insure capable men. Three types of tests are outlined, any one of which may be made the basis of qualifying welders; that is, for ascertaining whether a welder's experience is such as to enable him to properly perform work on steel buildings, which happens to be one of the simplest forms of welded construction. The best and most searching

1. Consulting Engineer, General Electric Co., Black Gap, Pa.
Presented at the Middle Eastern District of the A. I. E. E., Cincinnati, Ohio, March 20-22, 1929. Complete copies upon request.

qualifying test is to have the applicant weld a steel sample specimen in which the welds are subjected in a tension-testing machine to longitudinal shearing, to determine the ultimate stress. This longitudinal shearing strength is a measure of the welder's ability to weld, and if the average of his specimens is 42,000 lb. per square inch, or more, he should be acceptable. It is neither necessary nor desirable, for municipalities to require each welder to demonstrate his ability to the city's building inspector, but rather to require each contractor who fabricates or erects steel buildings to give evidence that his welders have qualified. The simplest way is for the contractor to have his welders make up some test specimens, submit these to a responsible laboratory for testing and exhibit the report of the laboratory as evidence of the welders' qualifications, all of which can be done under supervision of the architect's or engineer's inspector.

The average of a series of ten test specimens made by five welders in a steel fabricating shop is given as 44,000 lb. per square in., longitudinal shearing value, and although there is a variation of about 25 per cent between the strength of specimens made by the best and poorest welders, the results of each individual man are in very close agreement.

A good inspector can learn a good deal about a fillet by visual inspection. Rounded edges denote lack of penetration of fillet into parent metal; *i. e.*, into parts being welded; one short and one long side of a triangular fillet indicate that the wire electrode has been held at an incorrect angle of welding; a crater at any point in a fillet other than the end is evidence that the arc has been broken and the fillet not laid continuously; numerous gas holes on the surface of a fillet indicate too long an arc and a lack of penetration; a current (shown by the ammeter on the welding machine) too great for thin plates or too light for thick ones, is undesirable, and the inspector should see that the welders adjust their machines to obtain the current suitable for the thickness of the material being welded.

In comparing the lengths of fillets actually deposited in the shop with those designated on the drawings, it has been the writer's experience that generally the total of measured deposits exceeds the total compiled from drawings; but now and then an individual fillet may be either greater or less than designated. For example, at the welding shop of the American Bridge Company at Trenton, the total fillets on one welded truss aggregated 633⅛ linear in. as compared with 598 in. specified. And while the maximum excess of actual length of an individual deposit over that specified reached as much as 52 per cent, in two other fillets deficits of 8.8 per cent and 10 per cent, respectively, occurred. These deficits are not due exclusively to the welder, but sometimes may be attributed to inaccuracies on drawings where a specified length of fillet is impossible of execution.

Although sufficient tests are available to enable designers to proportion safe joints in ordinary building construction, additional tests are needed to provide for the future extensive use of welding which now seems assured. Two types of tests are possible; first, shearing; and second, direct-tension or compression.

In shear the welds are subjected to either transverse or longitudinal shear, and it is on the latter that very good test data are available, while on the former, some additional work should be done. Indeed, on longitudinal shearing tests, some interesting problems remain unsolved; these are; first, the relation between longitudinal shearing strength and lengths of fillets, or what amounts to much the same thing, the exact distribution of stress along the length of a given welded fillet; second, the relation between the longitudinal shearing strength and the size of the fillet; for example, will the strength per linear in. of a ½-in. fillet be double that of a ¼-in. fillet? Third, relation between longitudinal shearing strength and the number of layers used in depositing the fillet material.

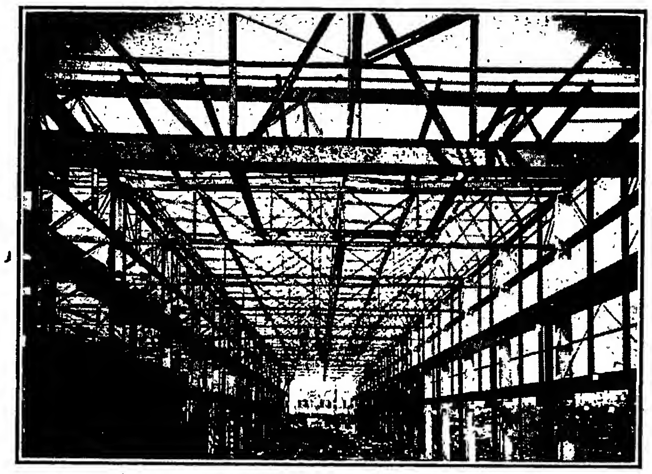


Fig. 2—Showing Building with 56-Arc-Welded Roof Trusses of General Electric Co. at West Philadelphia, Pa.

Existing tests indicate greater shearing strengths of fillets in transverse than in longitudinal shear.

Transverse shear appears in fillets laid at right angles to the axis of the member being connected, while longitudinal shear is exhibited in fillets laid parallel to the axis. For a member having a symmetrical cross-section, (rectangular, for example), one would expect transverse fillets to be stronger than longitudinal fillets, because each inch of fillet is subjected to the same stress, whereas in a fillet subjected to longitudinal shear, some inches are carrying little stress while others are working at the maximum. The case is analogous to a riveted joint, in that when a number of rivets are placed parallel to the stress, the load carried by the several rivets varies greatly; whereas when they are spaced in a row at right angles to the load, the rivets may be made to perform equal work.

Tensile and compressive stresses in welds are en-

countered in butt joints. Tensile butt joints are very common, as, for example, in longitudinal seams of tanks or pipes subjected to internal pressures. Compressive butt joints are much less frequently used. They may appear in splicing compressive members—a top chord of an ordinary truss for example,—but even here, splice plates with longitudinal shear on fillet welds might be used. For tensile butt welded joints,

FIG. 3—DETAILS OF COLUMN ANCHORS

ample data are available to enable us to design tanks, pipes and similar structures.

Typical test data for longitudinal shear of ⅜-in. fillets with triangular cross-sections presented in the paper show an average ultimate shearing strength of 13,354 lb. per linear inch of fillet corresponding to 50,200 lb. per square in. of minimum net shearing area of the fillet (the throat), *i. e.*, the section passing through the apex of the fillet's cross-section and perpendicular to its hypothenuse. The above longitudinal shearing values are found from specimens tested in tension, but those found from compressive specimens are quite considerably higher.

The American Welding Society's Committee on Building Codes has adopted a safe working unit shearing strength of 11,300 lb. per square inch which, for a ⅜-in. fillet in longitudinal shear is 3000 lb. per linear inch of fillet. Let us examine this. The throat distance of a ⅜-in. fillet being 0.266 in., the product of 11,300 and 0.266 gives 3000 lb. per linear inch. As the test data give 13,354 lb. per linear inch, or 50,200 lb. per square inch, these values of 3000 and 11,300 of the American Welding Society's Committee correspond to a factor of safety of 4.4 which is conservative.

Adopting 11,300 lb. per square inch for the safe allowable unit stress in longitudinal shear, the following working strengths are evident; for ½-in. fillet, 4000 lb. per linear inch; for ⅜-in. fillets, 3000 lb. per linear inch; for ¼-in. fillets, 2000 lb. per linear inch. Notice that for each ⅛ increase in size of fillet, an increase of 1000 lb. per linear inch in the allowable unit shearing stress is permitted.

THREE BUILDINGS IN WHICH ARC WELDING WAS USED

During the past year, the General Electric Company has completed a building in West Philadelphia, Pa., one in Bridgeport, Conn., and one in Pittsfield, Mass. in all of which the steel is connected principally by arc welding.

WELDED TRUSSES IN WEST PHILADELPHIA BUILDING

The West Philadelphia building consists of a head house 78 ft. wide by 171 ft. long, with vertical clearance of 43 ft. below bottom chords of trusses, of one aisle 59 ft. by 474 ft., and of a second aisle 79 ft. by 474 ft. These aisles and the head house comprise a building approximately 138 ft. by 552 ft. Supporting the roof over these various parts are trusses of the Pratt type with horizontal chords in the two main aisles and a sloping top chord in head house. Each chord is an 8-in. H section with horizontal web, while each diagonal consists generally of two small channels with their backs lying in contact with, and on the outside of, the vertical flanges of the H chords, to which the channels are welded by fillet welds. Ordinarily each vertical member of each truss is a 7-in. I-beam which fits into the trough of the top and bottom chords, to the vertical flanges of which it is welded. These direct connections of web

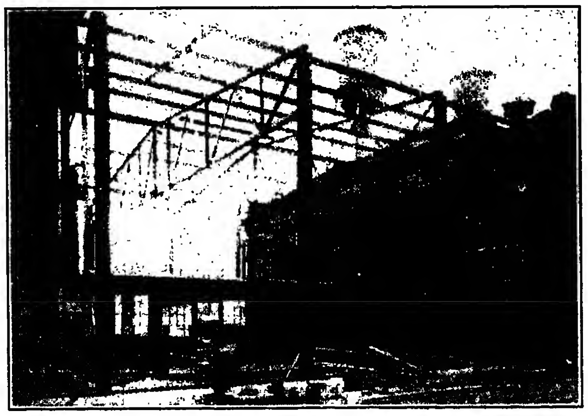


FIG. 4—WELDED TRUSSES ERECTED IN POSITION BETWEEN OTHER BUILDINGS

members to chords obviated the use of gusset plates at truss joints.

In any building consisting of a main aisle and a transept, especially where there is a traveling crane in the latter, the truss at the intersection of transept and head house is somewhat difficult to arrange. In this building, a truss 17½ ft. deep spans the main aisle, supports a portion of a roof load, the clear story, a roof truss in the head house, and a head house runway

girder spanning the 59-ft. aisle. On account of its depth, this truss was shipped in parts, assembled lying flat on the ground, welded, and erected. All other trusses were completely welded in the shop, and after erection, were welded to the supporting columns with sufficient bolts to hold them in position,

In addition to 10-ton bridge cranes in the head house and in the 59 ft. main aisle, this building has several smaller bridge and wall cranes.

Welded Trusses at Bridgeport, Conn.

The Bridgeport building code is a flexible one, in that it authorizes the Building Commission to permit the use of new materials if after investigation the Commission is satisfied that the new type is safe and satisfactory. After a study of tests data of welded joints, the Commission granted a permit for the General Electric Company's welded steel building which connects two existing buildings. This is a one-story structure with roof trusses of 62-ft. span supported on side wall columns. The interesting details here are the use of T-shaped top and bottom chords, the truss end bearings at the tops of columns and the splice at center of top chord. By cutting the web of an H section along its center, thus forming two T's for chords to which web members are welded directly, all gusset plates were eliminated. Beams can be cut in this manner either by cutting with the oxyacetylene flame, or by punching. At the bearing of vertical web of this top chord T on the base plate, which, in turn, rests on the column cap, stiffener plates are shop welded to the T-web.

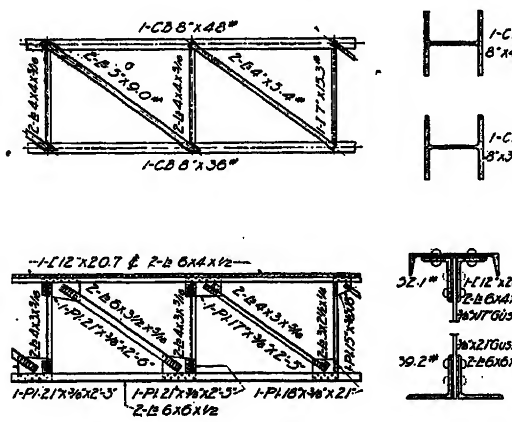


Fig. 5—Welded and Riveted Typical Panels and Chord Sections Pratt Type Truss

As the roof of this building slopes downward from the center line towards the ends of the truss, the top chord is given a similar contour, thus necessitating a splice in the top chord at the center. This is accomplished by a butt splice with a single V in the horizontal flanges of the T, while the vertical web is spliced on each side by a leg of a web member connected by fillet welds. As the roof trusses were fabricated completely in the shop by welding, the field welding consisted principally of connecting the top and bottom chords to the columns.

Welded Factory Building at Pittsfield, Mass.

This structure is two stories high in part, and three stories high elsewhere; length, 280 ft.; width, over-all, 60 ft., with approximately 40 ft. between centers of outside wall columns. The interest here lies entirely in the structural details, among which may be included the following:

a. Connection of a 27-in. main floor girder to the side wall column by a shop welded angle bracket upon which the girder rests and by field welding the girder web to face of the column as well as field welding the top and bottom flanges to the face of the column. The ends of these 27-in. girders were milled.

b. Connection of main 18-in. floor beams to web of 27-in. main floor girders by resting the beams on heavy angle brackets shop welded to girder webs. These seat angles were designed to take the loads to which they were subjected.

c. The use of flat bars as stiffeners welded to the vertical webs at the center of 27-in. main floor girders where these rest upon short columns extending from foundation to second floor level only.

All shop and field welding on the above buildings was performed by single operator, motor-driven generator sets. For depositing 3/8-in. fillets on metal 3/8 in. or more in thickness, the current was about 185 amperes,

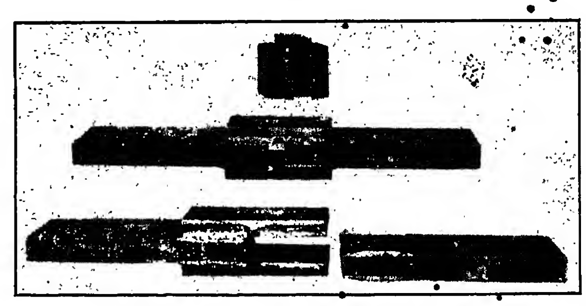


Fig. 6—Tests on Welded Structural Steel Showing Compression and Tension Specimens after Failure

3/16-in. electrodes, arc voltage 20, with smaller current values for smaller fillets on thinner steel.

The appendix[2] to this paper is a set of specifications for arc welding steel buildings, and covers the following subjects;—general application, definitions, quality of structural steel and welding electrodes, welding apparatus, workmanship, qualifications of welders, proportion of parts, protection of steel. These specifications may be used by architects and engineers for incorporation into contracts for structural steel buildings with the assurance that the provisions have in general been successfully tried out on several steel structures.

2. See complete paper.

ILLUMINATION ITEMS

Submitted by

The Committee on Production and Application of Light

THE PRESENT STATUS OF LIGHT SOURCES AND WINDOW MATERIAL IN LIGHT THERAPY

By W. W. Coblentz

Judging by the general publicity by high-pressure advertisements and discussions regarding ultra violet radiation therapy it would appear that we are all growing rickety and, hence, should bask in the sun when it shines or use artificial sources of light as a substitute.

This whole business is built up on the general observation that common window glass shuts out short wavelength ultra violet solar rays which prevent rickets[1] and are beneficial for general therapeutic purposes, as for example, the treatment of tuberculous ulcerations, etc.

But there is some evidence that the pendulum has swung to the extreme, and that within a few years we shall be back to normalcy. Recent experiments by Russell[2] at the New Jersey Agricultural Experiment Station indicate that there is a holdover, so that a thorough exposure to ultra violet light (at least in chicks) will continue to be effective for a week or two. From this it would appear that it will not be necessary to take sunbaths or artificial light baths so frequently as formerly supposed.

Concerning the use of special window glasses for transmitting ultra violet solar radiation, biological and other data are forthcoming showing that the use of these glasses will be more restricted than had been hoped for by those interested. For example, the measurements of Dr. Janet Clark,[3] at the School of Hygiene and Public Health, Baltimore, show that a child seated at a distance of 16 ft. from a north window would have to remain there some 15 to 20 hours in order to get as much ultra violet radiation as it would receive in two minutes out of doors, in sunlight at the noon hour. Such findings will no doubt put a quietus on the advocacy of special glass windows on the north side of school and office buildings. Similar results were obtained by Dr. Walter Eddy,[4] at Columbia University, who found that in order to prevent rickets it was necessary to expose the animals to the direct path of the sun's rays. This is in agreement with the tests made by Tisdall and Brown,[5] and published a year earlier, showing that for really beneficial results it is necessary to use a solarium facing south, so that the nude body can be exposed to the direct rays of the sun.

Rapid improvement is being made in the production of special window glasses which do not decrease much in transmission as a result of solarization on exposure to the sun. Glasses are now available which, after solarization, transmit 50 per cent or more of the vitalizing ultra violet rays shut out by common window glass. The demand is for a glass that transmits 50 per cent or more of the ultra violet rays. The public is willing to pay the price. Different melts of the same kind of glass vary greatly in transmission, and it is incumbent upon the manufacturer to send out only the melts that have the highest transmission.

Fortunately for the public, competition will practically force the glass manufacturer to increase the transparency of the glass to be used in solariums, because the manufacturer of artificial sources of ultra violet radiation, particularly of carbon arc lamps, can claim a share of the trade on the basis that the spectral energy distribution is similar to that of sunlight. It is to be noted, however, that while the radiation from the carbon arc lamp is the nearest approach to sunlight, it is not the same as sunlight. In fact, it is far from it. By using a special "white flame" type of impregnated carbon electrode and a special window glass for a screen that absorbs the short ultra violet rays and the long infra red rays which are not present in sunlight, the spectral quality of the radiation from the carbon arc is rendered more nearly like that of sunlight. Such lamps are now on the market, and since the dosage can be controlled, and the light can be used at one's convenience, it is a strong competitor of window glass in light therapy.

Whether it is important to have a spectral energy distribution similar to sunlight remains to be determined. At any rate it makes a good talking point. It is to be noted, however, that good biologic results have been obtained with the quartz mercury arc lamp, in which the radiation is emitted in a few strong emission lines which in no way resemble the energy distribution in the spectrum of sunlight.

The wholesale use of such devices is so new, even to the average practitioner, that it is well to proceed with caution. The advertising slogan "consult your physician" should probably be qualified to mean one who has had actual experience in the administration of this "modality."

1. See recent tests by Bethke & Kennard, *Poultry Science*, 6, p. 290, 1927.
2. Russell, Massengale and Howard, *Jour. Biol. Chem.*, 80, p. 155; 1928.
3. Clark, *Science*, 68, p. 165, Aug. 17; 1928.
4. Eddy, *Science*, 68, p. XII, October 19, 1928.
5. Tisdall and Brown, *Amer. Jr. Diseases of Children*, 34, p. 742, November 1927.

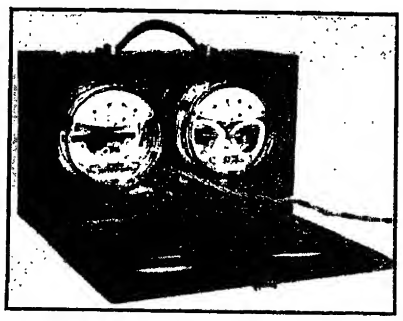
A DEVICE FOR MEASURING AVERAGE VOLTAGE

Particularly Adapted to Determination of Utilization Voltages

For some years, standards of illumination have been advancing steadily and will continue to do so as the value of good lighting becomes more and more generally recognized. In many cases the increased illumination is obtained by the simple expedient of putting higher wattage lamps in the old sockets without reinforcing the wiring to carry the additional load without excessive voltage drop. The unit cost of light (measured in terms of quantity received per dollar expended) will generally be increased by the under-

voltage burning that results from this increased voltage drop unless lamps of a lower voltage are used. The lighting service is rendered less uniform by excessive drop, because as the load increases or decreases, the voltage and consequently the light output per lamp will vary over a considerable range. During the period of heaviest use, when light is most in demand, the drop is greatest, the lamps are giving their lowest candle-power and the rate of loss is at a maximum. It is necessary, therefore, to know what the voltage conditions are in any plant or building, as a basis for obtaining the best possible service from the lighting installation.

This information can ordinarily be obtained by checking the voltage with indicating instruments, or by the use of curve-drawing voltmeters, tapped in right at the lamp. In the first case, however, considerable care must be used in selecting times of measurement and in estimating hours used. In the second case, the average voltage must be obtained by integration of a curve, and the equipment is rather expensive and requires careful handling and checking in order to obtain good results. To facilitate this sort of measurement, a new type of



Device for Measuring Average Voltage
(Mean square of average volts squared)

voltmeter has been tried out with very successful results. The instrument was constructed for use on a-c. circuits having fairly good frequency regulation.

The accompanying illustration shows the first attempt to produce an instrument of the kind desired. The box contains two standard watthour meter frames.

The one on the right is a kilowatt-hour meter which is standard in all respects except that it is built for a very small fixed load which is placed inside its own case. The current varies directly with the voltage, so that the wattage varies as the voltage squared and the readings of the instrument, therefore, are proportional to volts squared times hours. The gear train can be so chosen that if this meter is operated continuously at exactly 100 volts, its reading will correspond to the time in hours and tenths during which voltage was applied.

The second meter case (on the left) contains a synchronous clock motor, geared to the dials so that when supplied with 60-cycle current, it also reads hours and tenths directly.

The instrument is put in service by tapping it in to an extension plug inserted in the lamp socket, into which the lamp is screwed so that the voltage drop right up to the lamp terminals is taken into account. Both meters are read when the instrument is put in service.

After a period of time (say a day or two) both meters are read again. The differences of the readings show, for one meter, the hours the lamp was in use, and for the other, the hours times the volts squared. The second difference divided by the first gives the average of the volts squared. The square root of this figure then shows the square root of the average volts squared delivered at the socket during the time the lamp was actually burning. For the range of variation in operating voltage commonly encountered, the square root of the average volts squared will be practically the same as the average volts. As a matter of fact, as the light output and life of lamps both vary as powers of the voltage higher than the square, whatever departure there may be will increase the accuracy with which the average value of these quantities can be determined.

The process sounds complicated but it is really quite simple and gives results of a high order of accuracy. Undoubtedly the over-all dimensions and weight can be materially reduced as compared with those of the construction illustrated above. The instrument is accurate and not easily thrown out of adjustment. For use on d-c. circuits, the telechron could be replaced with a clock mechanism operated by a relay to record total hours in use, and a d-c. type of watt-hour meter would have to be used.

Every industrial plant and commercial building ought to check up, from time to time, the average voltage delivered at the lamp sockets to locate sections of the wiring system that need reinforcement or to determine what voltage of lamps should be used to correspond with that actually delivered at the sockets. A device of the kind described above will be found most useful for making such surveys.

A LIGHT AND SOUND SIGN

As part of its special Christmas decoration last year, one of the large Parisian Department Stores (Grands Magasins du Louvre) erected on the face of its building a large electric sign (about 160 ft. long and 80 ft. high) representing in colors a panoramic view of a fete on the River Seine. On the distant bank of the river, an impressive display of fire works was produced by flashing lamp effects, the appearance of the rockets, fountains, pinwheels, etc., being accompanied by realistic noises and explosions mechanically produced, and by smoke effects produced by steam. The cycle of operation required about twelve minutes, and then repeated. There were 15,000 lamps (ranging in size from 15 to 400 watts) used in the sign, which required nearly 50 miles of wiring and 35 motors for operating switches. The sign was made by the "Etablissements Jacopozzi."

Great crowds are said to have gathered every evening to watch the display.

INSTITUTE AND RELATED ACTIVITIES

Notice of Annual Meeting of Institute

The Annual Meeting of the American Institute of Electrical Engineers will be held in the New Ocean House, at Swampscott, Massachusetts, at 9.00 a. m. on Tuesday, June 25, 1929. This will constitute one session of the Annual Summer Convention, which is to be held in Swampscott, June 24-28.

At this meeting the annual report of the Board of Directors, also the report of the Committee of Tellers on the ballots cast for the election of officers will be presented.

Such other business, if any, as may properly come before an annual business meeting may be considered.

F. L. Hutchinson,
National Secretary.

Dallas Regional Meeting

A three-day Regional Meeting will be held under the auspices of the South West District of the Institute, with headquarters in the Adolphus Hotel, Dallas, Texas, May 7-9.

Four technical sessions are scheduled and also two Student Sessions, inspection trips, a lecture, a dinner-dance, etc. The technical papers deal with distribution systems, electrified oil-pipe lines, lightning, aviation lighting, telephony, radio program networks, waterworks and train signals.

The Student Sessions will be held on the afternoon of May 7 and the morning of May 8 respectively.

A complete program was published in the April issue of the Journal, page 319.

The Coming Summer Convention

EXCELLENT TECHNICAL PROGRAM AND DELIGHTFUL RECREATION PLANNED FOR MEETING AT SWAMPSCOTT, JUNE 24-28

A program crowded with pleasurable and profitable offerings is being arranged for the 1929 A. I. E. E. Summer Convention which will be held, with headquarters in the New Ocean House, at Swampscott, Mass., June 24 to June 28. All features which might make an enjoyable and worthwhile convention have been considered.

A selection of particularly high-grade technical papers has been made. These will deal with very live topics such as distribution systems synchronized at the load, automatic synchronizing, communication, electrical machinery, outdoor hydrogen-ventilated synchronous condensers, loading transformers according to temperature, shielding in electrical measurements, electrical heating elements, high-frequency electrical tools, etc.

Side View of the New Ocean House at Swampscott

Reviews of developments in all electrical fields will be presented in the annual reports of the Technical Committees of the Institute. The titles of the individual papers are given elsewhere in this announcement.

No locality is richer in opportunity for trips of engineering, scenic and historic interest. A large number of trips has been arranged.

For the recreational side of the program, a most enthusiastic local Convention Committee is planning many enjoyable events. Swampscott is an ideal place for a convention, combining sea-shore and country with excellent hotel facilities. Those who attended the 1923 Summer Convention at Swampscott remember the very enjoyable and successful meeting held at that time and it may be prophesied that the coming meeting will be equally as good.

Golf and tennis, a reception, a banquet, dancing and card playing will be some of the entertainment features. More information, particularly on the golf tournament, is given in later paragraphs.

The business side of the convention will include the Annual Meeting of the Institute, a report of the Committee of Tellers on election of officers for 1928-1929, the address of the President and presentation of prizes for papers.

The first Lamme Medal, which was awarded some months ago, will be presented to the medalist, Mr. A. B. Field of England.

There will be a lecture on the evening of June 25, by Dr. Harlowe Shapley; also several addresses at the banquet on June 26.

As customary at Summer Conventions, the first day will be devoted to conferences of Institute officers and delegates held under the auspices of the Committees on Sections and Branches. All members are invited to these conferences.

Reduced Railroad Rates

Reduced railroad rates on the certificate plan will be available for those attending the meeting from practically all points. By this plan the round trip will cost only one and a half times the one-way fare, provided 150 certificates are deposited at the Convention headquarters. These certificates must be obtained when visitors purchase their one-way tickets to Swampscott. Members of families are also entitled to obtain certificates. After 150 certificates have been deposited and the certificates have been validated, return tickets over the same route may be purchased for half the usual rate. There are certain restrictions regarding purchase dates, travel dates, etc., and local ticket agents should be consulted in every case.

OUTLINE OF CONVENTION PROGRAM

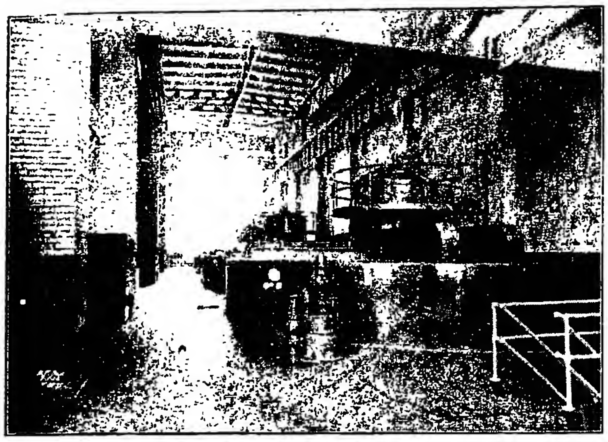
Monday, June 24

9:00 a. m.	Registration
10:00 a. m.	Conference of Officers and Section Delegates
12:30 a. m.	Section and Branch Delegates Luncheon
2:00 p. m.	Officers and Delegates Conference continued

2:00 p. m. Sports as scheduled; qualifying round for Mershon Cup
4:00 p. m. Branch Delegates Meeting
5:00 p. m. Afternoon tea
8:00 p. m. Informal dancing, cards

Tuesday, June 25

9:00 a. m. Registration
9:00 a. m. Annual Business Meeting
9:05 a. m. Address of Welcome—Gov. F. W. Allen
9:15 a. m. Report of Board of Directors (in abstract)



INTERIOR OF BELLOWS FALLS STATION OF NEW ENGLAND POWER ASSOCIATION SYSTEM

9:25 a. m. Report of Tellers; Introduction of, and response from, the President-Elect
9:35 a. m. Presentation of Prizes for Papers
9:45 a. m. President's Address
10:30 a. m. Two Technical Sessions, (a) Distribution and Power Plants; (b) Transportation
2:00 p. m. Trips as scheduled
2:00 p. m. Sports as scheduled. First round of matched play for Mershon Cup
5:00 p. m. Afternoon tea
8:00 p. m. Convention Lecture—Prof. Harlow Shapley of Harvard
9:15 p. m. President's Reception—dancing, cards

Wednesday, June 26

9:00 a. m. Social hour
9:30 a. m. Technical Committee Reports—2 Parallel sessions
2:00 p. m. Technical Session, (miscellaneous subjects)
2:00 p. m. Trips as scheduled
2:00 p. m. Sports as scheduled. Second (or third) round, Mershon Cup play; best nine holes out of 18
5:00 p. m. Afternoon tea
7:00 p. m. Convention Banquet
8:15 p. m. Presentation of Lamme Medal. Other banquet speakers
9:15 p. m. Entertainment, Mr. No Young Park, the Oriental Mark Twain. Music
10:30 p. m. Dancing, cards

Thursday, June 27—All-Day Trip to Rye Beach, Maine

9:00 a. m. Busses leave for trip along New England Coast to Rye Beach, Maine
9:30 a. m. Third round, Mershon Cup play
2:00 p. m. Final round, Mershon Cup play
5:00 p. m. Afternoon tea
6:30 p. m. Arrival from Rye Beach
8:30 p. m. Presentation of golf prizes, movies, dancing, cards

Friday, June 28

9:00 a. m. Social hour
9:30 a. m. Technical Sessions (a) Electrical Machinery, (b) Shielding in Electrical Measurements
2:00 p. m. Trips as scheduled
2:00 p. m. Sports as scheduled. Kickers' handicap
3:00 p. m. Start of Post-Convention Excursion through White Mountains
5:00 p. m. Afternoon tea
8:00 p. m. Informal dancing, cards

PAPERS FOR THE SUMMER CONVENTION

This list shows papers which are now proposed for this convention. Very probably one more paper will be added and possibly other changes will be made.

Distribution and Power Generation

Symposium on "Synchronized at the Load."

a. *Fundamental Plan*, A. H. Kehoe, United Electric Light & Power Co.

b. *Theoretical Calculations of System Behavior*, S. B. Griscom, Westinghouse Electric & Mfg. Co.

c. *System Tests and Operating Connections*, H. R. Searing and G. R. Milne, United Electric Light & Power Co.

Automatic Substations of Edison Electric Illuminating Co. of Boston, W. W. Edson, Edison Elec. Ill. Co. of Boston.

Rehabilitation and Rebuilding of Steam Power Plants, C. F. Hirshfeld, Detroit Edison Co.

Application of Induction Regulators on A-C. Distribution Networks, E. R. Wolfert and T. J. Brosnan, Westinghouse Electric & Mfg. Co.

Transportation

Electrification of the Mexican Railway, J. B. Cox, General Electric Co.

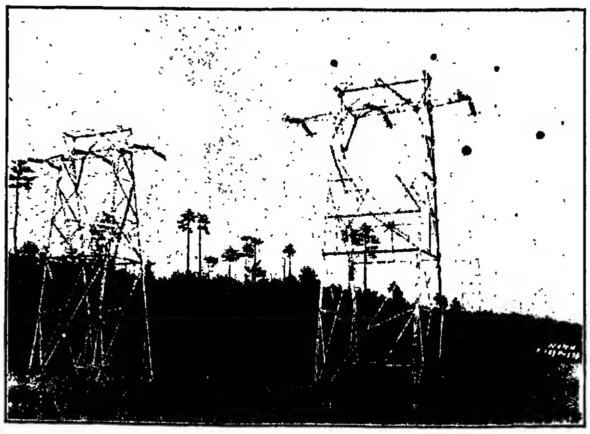
Contact-Wire Wear on Electric Railroads, I. T. Landhy, Illinois Central Railroad Co.

An Electrified Railroad Substation, J. V. B. Duer, Pennsylvania Railroad.

D-C. Railroad Substations, A. M. Garrett, Commonwealth Edison Co.

Miscellaneous

High-Frequency Portable Electric Tools, C. B. Coates, Chicago Pneumatic Tool Co.



MILLBURY-MEDWAY LINE TIE BETWEEN NEW ENGLAND POWER SYSTEM AND BOSTON EDISON COMPANY SYSTEM

Electrical Wave Analyzers for Power and Telephone Systems, R. G. McCurdy and P. W. Blye, American Tel. & Tel. Co.

Telephone Transmission Reference Systems, W. H. Martin, American Tel. & Tel. Co.

Design of Electric Heating Elements, Edwin Fleischmann, The Niagara Falls Power Co.

Electrical Machinery

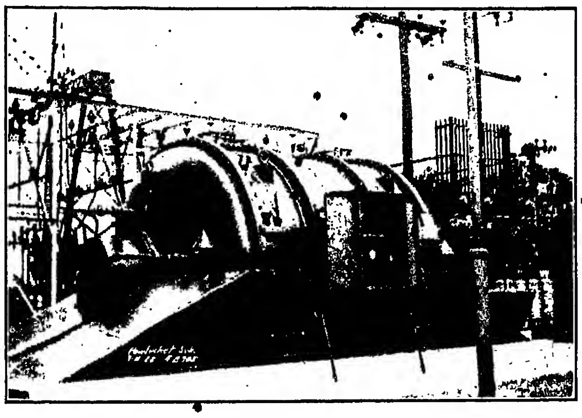
Safe Loading of Oil-Immersed Transformers, E. T. Norris of Ferranti, Limited.

Induction Motor Operation with Non-Sinusoidal Impressed Voltages, L. A. Doggett and E. R. Queer, Pennsylvania State College.

Outdoor Hydrogen-Ventilated Synchronous Condensers, R. W. Wieseman, General Electric Co.

Short-Circuit Torque in Synchronous Machines without Damper Windings, G. W. Penney, Westinghouse Elec. & Mfg. Co.

Analytical Determination of Magnetic Fields, B. L. Robertson and I. A. Terry, General Electric Co.



HYDROGEN COOLED ROTARY CONDENSER, PAWTUCKET SUB-STATION, NEW ENGLAND POWER ASSOCIATION SYSTEM

Shielding in Electrical Measurements

Shielding and Guarding Electrical Measuring Apparatus, H. L. Curtis, Bureau of Standards.

Some Problems in Dielectric Loss Measurements, C. L. Dawes, P. L. Hoover and H. H. Reichard, Harvard University.

Shielding in High-Frequency Measurements, J. G. Ferguson, Bell Telephone Laboratories.

Shielding of Cables in Dielectric Loss Measurements, E. H. Salter, Elec. Testing Laboratories.

Precautions against Stray Magnetic Fields in Measurements with Large Alternating Currents, F. B. Silsbee, Bureau of Standards.

Magnetic Shielding in Electrical Measurements, S. L. Gokhale, General Electric Co.

Technical Committee Reports

About eighteen reports will be presented reviewing the major activities in the fields of the various Technical Committees of the Institute.

TRIPS

The trips which may be taken are given below. Two special trips are being featured; one an all day trip and outing to Rye Beach, Maine, and the other a post-convention tour through the White Mountains. The all day outing will be taken on Thursday, June 27, and will prove a most acceptable opportunity for making friends and enjoying the entertainment which will be provided. The post-convention tour will start on Friday afternoon, June 28, and will end at Greenfield, (Mass.) or Boston on Monday, July 3. The trip will be through New Hampshire, Maine and Massachusetts and will take in many beautiful lake and mountain scenes. The complete cost will be $48.50, with return to Greenfield, and $54, with return to Boston. This includes all transportation and hotels (double rooms). The following is a list of all trips:

All-Day Outing at Rye Beach, Maine (June 27)

Trips to Colleges

Massachusetts Institute of Technology, Cambridge
Harvard University, Cambridge

Historical Trips

Concord and Lexington, and Wayside Inn, Sudbury
Historical excursion of Metropolitan Boston
Salem—including Old Witch House, the House of Seven Gables, and Marblehead,
Plymouth

Trips to Power Plants, Substations, etc.

Edgar Station, E. E. I. Co. of Boston, North Weymouth
Montaup Station, Fall River, including Dupont Station and A-C. Network, Brockton
Automatic D-C. substation, E. E. I. Co. of Boston, Cambridge Street, Boston, and automatic substations of Boston Elevated Railway Company
Automatic A-C. Substation of the E. E. I. Co. of Boston, Arlington, and automatic substation of Malden Electric Company, Medford
Automatic telephone stations in Boston and suburbs
Trip to Dorchester Station of Boston Edison Company

Trips to Manufacturing Plants

General Electric Works, Lynn
Navy Yard, Charlestown; Dry Dock, South Boston; and Ship Yards, Quincy
Gillette Safety Razor Company, Boston
United Shoe Machinery Company, Beverly
Condit Electrical and Manufacturing Co., Hyde Park
Simplex Wire & Cable Company, Cambridge
First National Stores, Somerville
New North Station Refrigerating Plant & Gardens, Boston
Champion Lamp Works of General Electric Company, Lynn

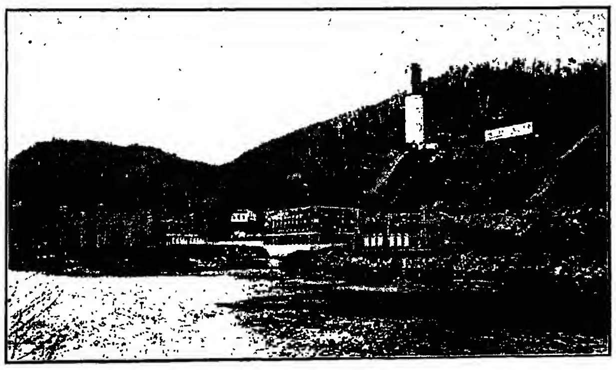
Other trips which may be arranged for special parties are:

Trip to College

Tufts College, Medford

Historical Trips

Boston Art Museum
Haverhill (Whittier's House)



HARRIMAN STATION OF NEW ENGLAND POWER SYSTEM
110-kv. and 66-kv. switch yards and surge tank

Trips to Power Plants, Substations, etc.

Electrification of Boston, Revere Beach, and Lynn R. R.
Service Buildings of E. E. I. Co. of Boston, Roxbury

Trips to Manufacturing Plants

Bethlehem Ship Building Yards, East Boston
Brown & Sharpe Company, Providence, R. I.
New England Confectionery Company, Cambridge
B. F. Sturtevant, Hyde Park
United Drug Company, Boston
Hood Rubber Company, Watertown

Hi-grade Lamp Company, Salem
Lever Bros., Cambridge
Naumkeag Mills, Salem
Watertown Arsenal, Watertown
Dennison Manufacturing Company, Framingham
Ford Assembling Plant, Somerville
Keith Shoe Company, Brockton

GOLF AND TENNIS

Both golf and tennis tournaments will be played on the excellent links and courts located near the hotel. The tournaments will be played for the respective Mershon Cups. It is proposed to present the prizes on Thursday evening and in order to accomplish this purpose all competition must be completed before Thursday evening. On account of the limited time and as the golf competition will be match play, the following information on the golf tournament is given:

The golf competition will consist of a qualification round (handicap medal play) of eighteen holes followed by match play (handicap).

The qualification round will be played on *Monday only*, June 24, 1929.

The sixteen low net scores will qualify for the match-play rounds.

No green fee will be charged members and registered guests. A representative of the Committee will be at the Club House at eight a. m. Monday, June 24, so that officers, section delegates, etc., who wish may play their qualification round early and still not miss their scheduled meetings.

In order to have as little interference as possible with business meetings and technical sessions, it is the wish of the Committee that play be restricted to the time of scheduled events, namely; Monday a. m. and p. m., Tuesday p. m., Wednesday p. m., and Thursday a. m. and p. m.

COMMITTEES

The 1929 Summer Convention Committee which is making the arrangements for the meeting consists of the following members who are officers of the committee or chairmen of other committees as indicated or general members: W. F. Dawson, *Chairman;* E. W. Davis, *Vice-Chairman;* H. B. Dwight, *Vice-Chairman;* C. S. Skoglund, *Vice-Chairman;* W. H. Colburn, *Secretary;* V. R. Holmgren, *Asst. Secretary;* H. P. Charlesworth, *Meetings and Papers;* W. B. Kouwenhoven, *Sections;* C. L. Edgar, *Finance;* C. A. Corney, *Trips;* F. S. Jones, *Transportation;* I. F. Kinnard, *Publicity;* W. E. Porter, *Hotel and Registration;* A. H. Sweetnam, *Sports;* Mrs. W. H. Timbie, *Ladies Committee;* J. P. Alexander, G. J. Crowdes, W. S. Edsall, S. J. Eynon, J. W. Kidder, R. G. Porter, W. H. Pratt, Ernest Shorrock, D. F. Smalley, H. B. Wood.

Fifth Session of International High-Tension Conference

June 6-15, 1929

The International Conference on High-Tension Systems, which was founded in 1921 under the auspices of the International Electrotechnical Commission will hold its fifth session in Paris, June 6th to 15th, inclusive. At the last session, 544 members coming from 28 countries took part, which shows the exceptional and world-wide interest in the proceedings of the Conference.

The coming session will give valuable opportunity for obtaining information regarding the technical progress of the last few years, together with the benefits to be derived from a personal touch with those working in other countries who have solved problems or who have, themselves, problems to solve. The proceedings will be carried on in English and French, with an interpreter present at each meeting to give every assistance required. As at the last conference, the French government will give its whole-hearted support.

Up to the date of this notice, 380 members from 21 countries have enrolled and 98 papers have been sent in from 18 different countries. The fee for the Conference is 250 fr. and in order to assist those planning to attend from abroad, the secretariat of the Conference offers any assistance possible to arrange in advance for accommodation in Paris to suit the convenience of all.

After the Conference the foreign committee in charge will arrange visits to installations of technical interest in the Pyrenees, the Alps, and the Riviera; it is hoped also to organize reunions with the Institution of Electrical Engineers of London for a summer meeting in Paris in June.

Address Organizing Secretary M. Tribot Laspière, 25 Boulevard Malesherbes, Paris or, for residents of the United States, Doctor C. O. Mailloux, 111 Fifth Avenue, New York.

Further Plans for Tokio

According to announcement made by Maurice Holland, Executive Secretary of the American Committee of the World Engineering Congress, (of which Doctor Elmer A. Sperry is Chairman), arrangements for the reception of 100 of Europe's most distinguished engineers and scientists who will arrive here during the summer enroute to Tokio have been placed in charge of Roy V. Wright, President of the United Engineering Societies, and Chairman of the New York Reception Committee. Mr. Wright will be aided by a committee of New York engineers which will plan inspection trips and arrange for our guests' entertainment and transportation while here.

It is expected that the foreign engineers will arrive in separate delegations of approximately forty each from Great Britain and Germany and the balance from Sweden, Denmark, France and Italy, probably during August and September.

The foreign delegation will sail from the Pacific Coast for Japan about the time that the American delegation, (now composed of 235 engineers and their families, from all parts of the country) sails from San Francisco. The American party has reserved a ship, and will embark at San Francisco October 12.

Serving with Mr. Wright on the New York Reception Committee are: Bancroft Gherardi, J. V. W. Reynders, F. R. Low, C. O. Mailloux, A. W. Berresford, H. Foster Bain, F. L. Hutchinson, Calvin W. Rice and George T. Seabury. Offices will be set aside for the visitors in the headquarters of the American Committee of the World Engineering Congress in the Engineering Societies Bldg., 29 West 39th Street.

The Exposition of Chemical Industries

The Twelfth Exposition of Chemical Industries, which opens May 6, 1929 at Grand Central Palace, New York, N. Y., bringing together most of the leaders in the chemical and allied industries in this country, will have over 450 exhibits of raw materials, chemicals, machinery, laboratory equipment, instruments of precision, etc., classified in the various sections. The exhibits of the various types of chemicals and machinery will permit the visiting engineer and executive to compare at first hand the various types of materials, equipment and chemical practises, with many new features exhibited for the first time.

Of particular interest to chemistry teachers will be the conferences on Tuesday, Thursday and Friday afternoons. It is expected that a number of professors will be present at these discussions to express opinions on the teaching of chemistry.

Reactive Power

A "Questionnaire on the Problem of Reactive Power" has been prepared by Prof. C. Busila, of the National Roumanian Institute for the Study of the Development and Utilization of Sources of Energy, for the Advisory Committee on Improvement of Power Factor, of the International Conference on Large High-Voltage Systems. At the direction of the Standards Committee of the Institute, an English edition has been published. This has had wide distribution both in this country and abroad.

A limited number of copies is still available and may be obtained by addressing H. E. Farrer, Secretary, Standards Committee A. I. E. E., 33 West 39th St., New York, N. Y.

The great importance of the questionnaire, representing as it does the most complete presentation thus far made of the various questions raised in regard to "power-factor and its improvement," renders it worthy of the most extensive consideration and publicity. Upon its reference to the Electrophysics Committee of the Institute, a sub-group of that committee was formed under the chairmanship of Dean O. J. Ferguson of the University of Nebraska to carefully study the questionnaire. This sub-group has asked that contributions be made upon the following points:

I. Acceptable definitions for reactive power under each of the following conditions:

1. Single-phase circuits, non-sinusoidal waves.
2. Polyphase circuits.
   (A) Sinusoidal waves, unbalanced circuit.
   (B) Non-sinusoidal waves.
      (a) Balanced circuit.
      (b). Unbalanced circuit.

II. Establishment of practical methods for the measurement of reactive power in each of the above cases.

III. Analysis of present reactive-power clauses in contracts, and establishment of a practical and fair basis for rate-making.

In approaching this problem, we recognize that we can limit ourselves to theoretically correct bases only in so far as these are capable of giving practicable methods,—*i. e.*, comfortable practise, without too great complexity or abstruseness. Rather than wander into involved conditions, we may have to make empirical and arbitrary agreements which will meet the further needs of practise. Rate-research committees, public service commissions, manufacturers, operators, consumers, laboratory investigators, research men; all these must be satisfied that our proposals are not inimical to their interests, but are usable with a fair degree of justice, comfort and simplicity and that the range of usefulness is recognized.

To whatever extent it is possible, new terms and multiplicity of methods must be avoided.

The subcommittee will be glad to have your constructive proposals upon certain points sent in duplicate to its secretary, Doctor M. G. Malti, Franklin Hall, Cornell University, Ithaca, N. Y.

1. Are all the important objectives included in the outline I have presented above? Are the statements sound?

2. Shall the study be directed by the Roumanian questionnaire, or shall a base be established along some such lines as above?

3. What direction of approach will be most effective,—theory or practise?

AMERICAN ENGINEERING COUNCIL

CONFERENCE OF ENGINEERING SECRETARIES TO BE HELD IN CHICAGO, JUNE 6-7, 1929

The call for the Fourth Conference of Secretaries of Engineering and Allied Technical Organizations has been issued by Mr. L. W. Wallace Executive Secretary of American Engineering Council, 26 Jackson Place, Washington, D. C.

The meetings will be held in the rooms of the Western Society of Engineers, 205 W. Wacker Drive, Chicago, Ill., as guests of the Society.

The invitation was issued from the headquarters of American Engineering Council, April 4.

A. S. C. E. JOINS COUNCIL

With the approval of Council Delegates, the American Society of Civil Engineers, with headquarters at 33 West 39th Street, New York, N. Y., has been admitted to membership in American Engineering Council. The American Society of Civil Engineers was organized in 1852 and has a membership as of January 1, 1929, of 13,577 professional engineers.

The application was submitted April 3, 1929, in accordance with authorization of its Board of Direction, given on January 15, 1929 and the delegates thus far selected by the A. S. C. E. are;

For the term ending January 1, 1930; Baxter L. Brown, St. Louis, Mo.; L. L. Calvert, Philadelphia, Pa.; A. J. Dyer, Nashville, Tenn.; George T. Seabury, New York; C. E. Grunsky, San Francisco, Calif.; and Frank N. Gunby, Boston, Mass.

For the term ending January 1, 1931: H. S. Crocker, Denver, Colo.; A. J. Hammond, Evanston, Ill.; John C. Hoyt, Washington, D. C.; Anson Marston, Ames, Iowa; Francis Lee Stuart, New York, N.Y.; and Frank M. Williams, Albany, N. Y.

STREET TRAFFIC REPORT DISTRIBUTION PROGRESSING

The initial supply of 10,000 copies of American Engineering Council's Report on Street Traffic Signs, Signals and Markings is nearing exhaustion with the distribution which was begun the first of February, 1929. Through their local sections, all of the national engineering societies are cooperating in bringing this report to the attention of the municipal authorities throughout the country, American Society of Civil Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers having done especially active work in this regard.

The distribution of this report brings very forcibly to the attention of American Engineering Council the need for established engineering agencies in each state in the Union, in order that such matters may come to the attention not only of engineers, but the general public. Some states are cared for by state engineering societies; others have state engineering councils organized in much the same manner as American Engineering Council. Organizations in the following twenty states have definitely accepted responsibility for sponsoring the presentation of the traffic report in their respective states; Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Oklahoma, Pennsylvania, Rhode Island, Tennessee, Virginia, Wisconsin and Wyoming.

Arkansas, Arizona, Colorado, Idaho, Montana, Nebraska, Nevada, New Mexico, North Carolina, North Dakota, Oregon, South Dakota, Texas, Utah, Vermont, and Washington have organizations which have been approached to handle the distribution of the report, but have not as yet reported what action has been taken, and there are twelve additional states in which agencies are yet to be selected for this public service.

In addition to American Engineering Council, two other national agencies have performed excellent service in the distribution of this report. The U. S. Chamber of Commerce, under the direction of Col. A. B. Barber, has distributed over 3500 copies through the various chambers of commerce, and the American Automobile Association, under Ernest Smith, has distributed approximately 1500 copies. Both the U. S. Chamber of Commerce and the American Automobile Association were participating agencies in the preparation of this report.

ENGINEERS IN PUBLIC LIFE

A recent canvass by American Engineering Council of governors of all states, and members of the Senate and House of Representatives discloses many engineers holding responsible positions in the political life of the nation.

Those listed are divided into three classes,—those who are, or were at the time of their election to public office, professional engineers both by training and experience; those who have been engaged in work which is essentially engineering and which requires the engineering mode of thinking and method of approach; and those who have received their basic training and education in engineering with a B. S. degree in an engineering school, but subsequently developed fields of other activity.

The governors who are professional engineers are Clayton D. Buck of Delaware, George H. Dern of Utah, F. C. Emerson of Wyoming, Morgan F. Larson of New Jersey, and George A. Parks of Alaska.

Governor John H. Trumbull of Connecticut has received no engineering degree, but has been engaged in the manufacture of electrical machinery, having been President of the Trumbull Electric and Manufacturing Company, Chairman of the Board of Colonial Air Transport Company, Director of the Hartford Steam Boiler Inspection Company and similar enterprises. Governor Bibbs Graves of Alabama, although a lawyer, received his first degree as a Batchelor of Civil Engineering, University of Alabama. Governor O. M. Gardner of North Carolina, was a student at the State College of Agriculture and Engineering and received Bachelor of Science degree from the University of North Carolina. Governor Harry S. Leslie of Indiana, received the degree of Batchelor of Science from University of Purdue.

Two recent and well-known ex-governors are professional engineers: James G. Scrugham of Nevada and James Hartness of Vermont, Past-President of American Engineering Council.

The above names show a decidedly increasing tendency of the public to trust men of engineering training with public office. In 1920 there were but two governors of states who could be placed in one of these three classes; in 1910 also there were but two.

In the U. S. Senate of the 70th Congress there were five men with engineering training and experience: Vice-President Charles Dawes, who served as a major of the 17th Engineers, U. S. A., was in the Engineer Corps during most of his experience in the World War, and is Past-President of the American Society of Military Engineers; Senator R. B. Howell of Nebraska is a civil engineer, a graduate of the U. S. Naval Academy, and at one time City Engineer of Omaha and State Engineer of Nebraska; Senator H. W. Keyes of New Hampshire, although a lawyer, received the B. S. degree from New Hampshire College; Senator Tasker L. Oddie of Nevada, is a member of the A. I. M. & M. E. Senator Millard E. Tydings of Maryland is a graduate of the Maryland Agricultural and Mechanical College in the School of Mechanical Engineering. This shows a decided increase in the number of men in public office who have engineering experience. In 1920 the Senate had but two men who could be placed in these classifications, and in 1910, there were but three.

The House of Representatives does not show such a marked increase of membership of those who have engineering training and experience. Nevertheless, there has been a steady increase since 1910. In 1910 it included three professional engineers and three members with engineering experience. Also, three with Bachelor of Science degrees. The House of Representatives in 1920 contained two men with engineering experience and thirteen who had received B. S. degrees.

The House of Representatives of the 70th Congress, 1929, contained a total of 21 members with engineering training or experience.

Five Engineers who may be classed as professional engineers are in Congress, They are:

L. W. Douglas of Arizona, who studied mining and metallurgical engineering at M. I. T. and has six years of mining experience. H. L. Englebright of California, who graduated in mining engineering at the University of California. S. S. Arentz of Nevada, who is a mining engineer and graduated from the South Dakota Schools of Mines. (Past-President of the Utah Society of Engineers) Ernest R. Ackerman of New Jersey has been a member of the N. J. Geological Survey. J. T. Deal of Virginia is a civil engineer and a graduate of Virginia Military Institute.

Members of the House of Representatives, 70th Congress who have had some engineering experience are, Paul J. Moore of New Jersey, Wm. L. Carss of Minnesota, John McSweeney of Ohio, Franklin Menges of Pennsylvania, and Louis Monast of Rhode Island.

Those who have had training in some engineering institution and in most cases have received B. S. degrees from an engineerng college are: R. A. Green of Florida, L. J. Dickinson of Iowa, W. B. Gregory of Kentucky, David Kincheloe of Kentucky, W. P. Martin of Louisiana, W. P. Cole of Maryland, Jess Bushby of Mississippi, F. N. Hale of New Hampshire, A. J. Griffin of New York, George C. Peery of Virginia and E. T. England of West Virginia.

STATES INTERESTED IN WATER RESOURCES

There is a movement on foot among the various States of the Union to create an agency or empower an existing agency with authority to act in all matters appertaining to the water resources of the particular state. A number of legislatures are considering measures of this character.

One of the first states to pass such a measure is the State of North Carolina, the act as passed being a combination of House Bill 1149 and Senate Bill 1403, entitled, "An Act Providing for Administration and Control Over Interstate Waters."

The John Fritz Medal Presented to Mr. Hoover

At a luncheon given by Mr. Hoover to present and past members of the Board of Award, preceding medalists, and presidents and secretaries of the American Societies of Civil, Mining and Metallurgical, Mechanical and Electrical Engineers the John Fritz Gold Medal for 1929 was presented to President Herbert Hoover at the Executive Mansion, Washington, Thursday, 25th April.

This medal is the highest honor bestowed jointly by the four national engineering societies, whose membership is 60,000. It is awarded annually for "notable scientific or industrial achievement, without restriction on account of nationality or sex." In accordance with custom, the award to Mr. Hoover was made tentatively and without announcement in October 1927 and was formally confirmed and announced one year later.

At the presentation, Dean Dexter S. Kimball, of Cornell University, Chairman of the present Board of Award, presided and gave a brief history of the medal. General John J. Carty, Past-President, American Institute of Electrical Engineers, and former member of the Board of Award, spoke briefly of the human elements of Mr. Hoover's life work. Dr. John R. Freeman, Past-President of the American Society of Mechanical Engineers and of the American Society of Civil Engineers, and a former member of the Board of Award, spoke of Mr. Hoover's work as an engineer; and Mr. J. V. W. Reynders, Past-President of the American Institute of Mining and Metallurgical Engineers and Chairman of the Board which made the award to Mr. Hoover, presented the medal, with the accompanying certificate, which read in part: "To Herbert Hoover, engineer, scholar, organizer of relief to war stricken peoples, public servant." Mr. Hoover responded with a brief address expressing his high appreciation of the honor conferred by the award of the medal.

The luncheon which followed the presentation ceremonies was attended by President and Mrs. Hoover and the delegation of forty-two engineers. The A. I. E. E. delegation included President Schuchardt, National Secretary Hutchinson and the following eighteen Past-presidents: Messrs. Adams, Arnold, Berresford, Buck, Carty, Chesney, Dunn, Ferguson, Gherardi, Jackson, Jewett, Kennelly, Mailloux, McClellan, Osgood, Rice, Jr., Scott, and Stillwell.

International Congress on Steel Construction

In connection with the international exposition of leading industries at Liege, Belgium in 1930, the sciences and their application, and ancient walloon art will be reviewed by American engineers, steel manufacturers and others interested, who are invited to participate in an International Congress of Steel Construction in Liege, Belgium, and to present papers or to

contribute to the discussions. Suggestions for the program, if sent soon, will be welcomed. Intention to participate should be made known promptly so that future bulletins may be sent to persons interested. The Organizing Committee appeals to foreign specialists to send papers on problems which they have studied, besides becoming members of the Congress. Each national committee is requested to designate a reporter for each division of the general subject, this reporter to summarize the contributions from his country and to send the papers and reports to the Executive Committee in Belgium. A general reporter for each division will later be appointed to correlate all information for the Congress and start discussion. Papers will be furnished in advance copy form and the Executive Committee would therefor, like to receive the papers and reports by September 1929 to insure printing and distribution well in advance. The four days of the congress will be between August 15 and September 15, 1930. The official languages will be English, French and German; papers to be published in their original languages with summaries probably in all three languages.

In order to receive preliminary publications of the Congress, the fee of 35 belgas (approximately $5) should be sent to Congres International de la Construction Metallique, 4 Place Saint Lambert, Liege, Belgium, together with registration as follows:

(Full name)..

(Profession or business)..

(Full address)..

registers for the Industrial Congress of Steel Construction at Liege in 1930.

He intends to participate in the activities of the Congress..

He is especially interested in the following subject:..

Date.................................... Signature....................................

A rooming service will be organized. There will be interesting excursions and social features. Ladies are invited and their visit will be made enjoyable.

Americans are urged to collaborate because of their notable achievements in structural steel.

Cincinnati Holds Regional Meeting

The fifth Regional Meeting of the Middle Eastern District of the Institute was held in Cincinnati, Ohio, with headquarters at the Hotel Gibson, on March 20-23. About 270 were registered for the meeting. Four technical sessions were held at which 17 papers were presented. A report of these sessions is given below. A Student Activities session was another feature, and there were several inspection trips and a convention dinner.

At the Student Activity Session there were three addresses as given below, and a number of short reports by Branch representatives. The addresses were as follows: *The Student Branch as a Part of the Institute Organization*, by H. H. Henline; *The Student Convention, Its Purposes and Procedure*, by Morland King, and *Report on Work of Student Branches*, by L. A. Doggett. Fifteen Students then presented two-minute reports of the activities of their respective Branches. This part of the program was announced as a competition and prizes were awarded later for the reports which were considered best as follows: A first prize of $10 to R. B. McIntosh, Case School of Applied Science, and a second prize of $5 to C. C. Coulter, West Virginia University.

In addition to this meeting the Students and Branch Counselors attended luncheons on March 20 and 21. Great interest was shown in the meeting by the Students of whom 57 were registered. More information on the discussion at the luncheons is published in this issue of the Journal under "Student Activities."

In the opening session on March 20, J. L. Beaver, Vice-President of the Institute in the Middle Eastern District, made a short address. He was followed by Charles Eisen, President Pro-tem of the Cincinnati Council who delivered a short speech of welcome.

At the convention dinner held on the evening of March 21 both President R. F. Schuchardt and Vice-President J. L. Beaver spoke. Then C. M. Newcomb talked very interestingly on the subject "What Are You Afraid Of?" Prof. A. M. Wilson presided at the dinner.

Several inspection trips were scheduled to power and industrial plants.

A unique demonstration which attracted wide attention was made on the first evening of the meeting. On this evening an airplane flew over the city and when directly above the Hotel Gibson, the letters "A. I. E. E." appeared in lights on the bottom side of the plane's wings. An instant later by means of a radio impulse sent by the pilot from the plane, a set of floodlights on the hotel was switched on, thus suddenly illuminating a large fountain in front of the hotel.

Report of Discussion

The following paragraphs give a summarized report of the discussion at the technical sessions. The papers presented at each session are listed and are followed by an account of the main points covered by the discussors. The complete discussion will be published in the Transactions immediately following the respective papers:

General Session

Recent Developments in Telephone Construction Practises, by B. S. Wagner and A. C. Burroway.

Illumination of Airports and Airways, by H. E. Mahan.

Iron Losses in Turbine Generators, by C. M. Laffoon and J. E. Calvert.

In connection with the paper on telephone construction, C. A. Jaques asked if damage to cable sheaths is likely to result from forcing gas at 40 lb. pressure into the cable. Mr. Wagner replied that any pressure below 50 lb. may be used with safety.

After presenting his paper Mr. Mahan was asked about the suitability of the arc lamp and the neon lamp for airport lighting. He stated that illumination from the arc lamp is quite satisfactory but that it has the disadvantage of requiring a man to operate it. He said that although the neon lamp has been advocated as especially efficient in piercing fog, recent tests have shown that it is not better than the incandescent lamp in this respect.

In discussing the third paper, L. A. Doggett asked if there are any experimental data which confirm the theories presented. Mr. Calvert said he had obtained very little experimental confirmation, though it is possible to get such data by very tedious methods.

Automatic Stations and Welding Session

Street Railway Power Economics, by J. A. Noertker.

Automatic Mercury Arc Rectifier Substations in Chicago, by A. M. Garrett.

Arc Welding of Steel Buildings and Bridges, by F. P. McKibben.

Fabrication of Large Rotating Machinery, by H. V. Putman.

T. H. Schoepf, discussing Mr. Noertker's paper, said he believed that the fixed charges of 12 and 15 per cent respectively, as advocated in the paper, are too high. He claimed also that a charge of 2 per cent for taxes may not be correct as taxes are fixed rather arbitrarily by local boards. J. C. Bailey questioned the choice of 1000-kw. converters instead of 750-kw. machines as the smaller machines would operate at higher load (75 per cent of rated load) and thus at a more efficient point. He stated that his company has found the d-c. type of control for automatic stations superior to the a-c. type. In answer to Mr. Schoepf, Mr. Noertker explained that his figures for return on the investment include 2 per cent margin because the franchise of his company limits the return to 6 per cent. In replying to Mr. Bailey he stated that there were two reasons why the 1000-kw. converters were chosen, (1) the 750-kw. converter is a faster ma-

chine (1200 rev. per min.) and is subject to higher maintenance costs, and (2) the 1000-kw. machines were placed in outlying territories where a growth of load is expected which could not be carried by the 750-kw. machines.

In commenting on Mr. Garrett's paper, Otto Naef pointed out the trend of substituting a large number of small automatic substations for a small number of large stations. J. G. Swallow stated that on the Illinois Central System there has resulted a gain in efficiency of 17 per cent on a capacity factor of 12 per cent when rectifiers were substituted for rotating converters. Mr. Garrett said that in his experience the gain in efficiency is great if the machine operates at low loads. In answer to a question by J. A. Noertker, he said that if a tank is opened only for inspection or cleaning the mercury the rectifier can be put back into operation in a very short time. If a new anode or insulator is needed considerable time is required to make the change and to season the machine before again putting it into operation; sometimes as much as 75 or 100 hr. being required.

In answer to several questions on his paper Prof. McKibben stated that visual inspection is the only inspection applied to riveted joints in structural work. He explained that dependence is placed largely on the ability of the welders who must pass very thorough tests before they are employed. He stated that welds made by the electric arc and the oxy-acetylene flame have the same strength. Atomic-hydrogen arc welding he said makes a denser weld with slightly higher elastic limit but no greater tensile strength. The atomic-hydrogen process he stated is not applicable to a building. He stated that many shops build up worn parts of machines by welding, such as flanges, shafts, etc. On this point H. V. Putman said that his company does not permit welding on shafts as residual stresses are produced which may cause failure under vibratory forces.

In answer to questions on his paper Mr. Putman explained that the increased permeability of welded machine frames is not a factor in the reduction of weight. He said that welded construction of machine spokes has eliminated the necessity for blowers on low-speed machines, while the windage loss is about the same.

High-Speed Instruments and Measurements Session

High-Speed Photography in Electrical Engineering, by H. W. Tenney.

Oscillographs for Recording Transient Phenomena, by W. A. Marrison.

A New Type of Hot-Cathode Oscillograph, by R. A. George.

Bushing-Type Current Transformers for Metering, by A. Boyajian and W. F. Skeats.

Excitation of Current Transformers under Transient Conditions, by D. E. Marshall and P. O. Langguth.

Morton Sultzer showed and explained a number of oscillograms taken with the instruments described in Mr. Marrison's paper.

In answer to several questions by W. L. Everitt, Mr. George said that if the filament in his oscillograph were sealed in a tube, a long life would probably result. At present he said the life has not been long though it has sometimes run to 30 or 40 hr. The principal trouble he said has been caused by light oil vapors from the vacuum pump which apparently reduce the oxide on the filament. He stated that there is not any appreciable dispersion of the beam at pressures less than 10 or 15 microns. He explained that for moving the film from outside the tube a rod is used which passes through a joint packed with cotton covered with heavy grease.

In discussing the paper on current transformers, C. T. Weller claimed that the accuracy of the modified method described is inferior to that of the standard two-stage method. Mr. Boyajian stated that this is not true if the "auxiliary impedance" is made of the correct value. A. M. Wiggins suggested that by using high-grade core material such as hypernik, good results might be obtained without the complicated design described by Messrs. Boyajian and Skeats. Mr. Boyajian agreed with this but claimed that with a given material the two-stage transformer will give greater accuracy than the single-stage.

Power Systems Session

Electrical Equipment of Bar Plate and Hot Strip Mills, by J. B. Ink.

Fused Arcing Horns and Grading Rings, by P. B. Stewart.

Operating Experience with the Low-Voltage A-C. Network in Cincinnati, F. E. Pinckard.

Quick-response Generator Voltage Regulator, by E. J. Burnham. J. R. North and I. R. Dohr.

Cathode Ray Investigation of Transmission Lines with Artificial Lightning, by K. B. McEachron.

In connection with Mr. Stewart's paper, R. L. McCoy said that laboratory tests indicate that the fused arcing horns will be suitable for 110- and 132-kv. lines. S. M. Hamill, Jr., emphasized the rapidity of the fuse's action which is quicker than the fastest relay setting of about 9 cycles. C. L. Fortescue stated that his company is attempting to achieve similar results by incorporating into an insulator string the properties of a lightning arrester. O. S. Clark stated that tests have shown that there is only a remote possibility that both fuses in the arrangement will blow at the same time. H. C. Don Carlos asked if conditions warrant the expense of installing these rings and fuses. His company he said operates without any grading rings and has practically no outages caused by lightning. Mr. Stewart pointed out that lightning is more frequent on his own company's lines and that two and three parallel circuits sometimes flashover at the same time.

F. C. Hanker, in discussing the paper by Messrs. Burnham, North and Dohr, stated that there are two ways of handling large loads placed suddenly on a system, (1) by using machines having suitable inherent regulation and (2) by using a quick-response regulator as described in the paper. R. M. Carothers pointed out that the vibrating type regulator also can be arranged for quick response. Mr. Burnham in answer to a question stated that special light contactors are used in the regulator.

C. L. Fortescue, in connection with the last paper outlined some artificial lightning tests which his company is making on a 220-kv. line now under construction. In these tests he hopes to obtain valuable data on the impedance of tower footings. Such tests, he stated, are much preferable to tests on small-scale models. A. M. Opsahl described in more detail the tests on the 220-kv. line mentioned by Mr. Fortescue. W. L. Everitt suggested that the effects of transients on transmission lines might be predicted by analyzing the lines in terms of bands of frequencies as is done on communication lines. In answer to a question Mr. McEachron stated that in his tests the disturbing effect of the capacity of the cathode ray oscillograph is about equal to that of a string of insulators.

Nation-Wide Radio Hook-Up on Safety

In cooperation with the National Safety Council, the National Broadcasting Company announces definite dates for five of the thirteen speakers who will deliver weekly radio addresses in connection with the "Universal Safety Series," which began April 20, with an initial speech by Charles M. Schwab, Chairman of the Board, Bethlehem Steel Company, on "Safety a Factor in Industry" prefaced by a few introductory remarks by Henry A. Renlinger, president of the National Safety Council. On May fourth program has scheduled as its speaker P. R. Crowley, President of the New York Central Railroad and the weekly programs from then on will include such men as Col. Robert P. Lamont, Secretary of Commerce ("Safety—a National Problem"); Doctor Miller McClintock, Director of the Albert Russell Erskine Bureau of Street Traffic Research, Harvard University ("Making our Highways Safe"); Mr. Grover A. Whalen, Police Commissioner of New York City ("Enforcement as an Aid to Safety"); J. E. Sheedy, Executive Vice-President of

the United States Lines, New York City, ("Safety on the High Seas") and the Honorable James J. Davis, Secretary of Labor ("Safety of the Worker"). Four additional subjects will be, "Education—the part it plays in Safety," "The Automobile and Safety," "Safety in the Air" and "Summing Up." Already 26 stations are included in this hook-up and there are others to join if a rearrangement of their present schedules will permit.

A. I. E. E. Directors Meeting

The regular meeting of the Board of Directors of the American Institute of Electrical Engineers was held at the Hotel Gibson, Cincinnati, Ohio, on Thursday, March 21, 1929, during the Cincinnati Regional Meeting of the Institute.

There were present: President R. F. Schuchardt, Chicago, Ill.; Vice-Presidents O. J. Ferguson, Lincoln, Neb.; J. L. Beaver, Bethlehem, Pa.; A. B. Cooper, Toronto, Ont.; C. O. Bickelhaupt, Atlanta, Ga.; W. T. Ryan, Minneapolis, Minn.; Directors E. C. Stone, Pittsburgh, Pa.; C. E. Stephens, New York, N. Y.; H. C. Don Carlos, Toronto, Ont.; F. J. Chesterman, Pittsburgh, Pa.; F. C. Hanker, East Pittsburgh, Pa.; E. B. Meyer, Newark, N. J.; J. Allen Johnson, Niagara Falls, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; National Secretary, F. L. Hutchinson, New York, N. Y. By invitation, Professor Harold B. Smith, presidential nominee, Worcester, Mass.

The minutes of the Directors meeting of January 30, 1929, were approved.

Approval by the Finance Committee, for payment, of monthly bills amounting to $24,174.99, was ratified.

Upon the committee's own recommendation, the Finance Committee was authorized to invest at this time, $10,000 now available of the sum set aside in the budget for the Reserve Capital Fund.

The Board ratified the action of the Executive Committee, under date of March 11, on pending applications, as follows: 207 applicants were admitted to the grade of Associate; 14 applicants were elected to the grade of Member; 11 applicants were transferred to the grade of Member; six applicants were transferred to the grade of Fellow; 349 Students were enrolled.

Reports were presented of meetings of the Board of Examiners held February 20 and March 6, and the actions taken at those meetings were approved.

In accordance with the request of the District officers, approval was given to holding the already authorized Louisville Regional Meeting during the week of November 17-21, 1930.

Upon the recommendation of the Chairman of the Sections Committee, authorization was given for the organization of a North Carolina Section of the Institute.

Consideration was given to three communications from the Standards Committee, and in accordance with the recommendations contained therein the following actions were taken:

Approved for adoption as an Institute Standard and for submission to the American Standards Association, the standard for Four-pin Vacuum Tube Bases, developed by the Sectional Committee on Radio, for which the Institute is joint sponsor with the Institute of Radio Engineers;

Approved action of Standards Committee in declining an invitation to appoint a representative on the Sectional Committee on Standardization and Unification of Screw Threads, issued by the American Society of Mechanical Engineers, co-sponsor with the Society of Automotive Engineers for this project;

Approved the deletion of Rule 16000 (Standards for Heating Devices) of 1922 edition of the A. I. E. E. Standards, which has never been replaced in the general work of revision of the Standards; this action being taken because the rule "provides, in the opinion of the Standards Committee, for a test of such a low value under present conditions that if put into use, it might cause considerable trouble."

Mr. L. A. Ferguson was reappointed a representative of the Institute on the Commission of Washington Award, for the two-year term beginning June 1, 1929; and Mr. F. W. Peek was nominated, for appointment by the President of the National Academy of Sciences, as a representative of the Institute on the Division of Engineering and Industrial Research of the National Research Council, for the term of three years beginning July 1, 1929, to succeed Mr. Cary T. Hutchinson, whose term expires at that time and who is ineligible for immediate reappointment.

The Board confirmed the appointment by the President of the following Tellers Committee to canvass and report upon the votes cast by the membership for the 1929 election of Institute officers: Messrs. W. E. Coover (Chairman), W. C. F. Farnell, Alek Johnson, R. R. Kime, E. J. O'Connell, R. A. Rich, and John T. Wells.

In acceptance of an invitation from the American Society of Civil Engineers to designate an Institute member to serve on a committee to make recommendations to the A. S. C. E. Board of Direction in regard to the award of the Alfred Noble Prize, it was voted to appoint, each year, the Chairman of the A. I. E. E. Committee on Award of Institute Prizes for the past year.

Consideration was given to a request from the American Committee of the World Engineering Congress, Tokio, October 1929, to designate, from the list of prospective members of the American party prepared by the office of the American Committee, seven official delegates of the Institute to this Congress. It was voted that the President and the National Secretary be appointed as two of the seven, and that the President name the remaining five delegates.

Other matters were discussed, reference to which may be found in this and future issues of the JOURNAL.

Annual Report of Engineering Societies Library

The following is an abstract of the Annual Report of the Library Board to the United Engineering Society and to the Founder Societies for the year 1928 presented at the annual meeting of the Library Board on January 10, 1929.

During the year, the recorded visitors numbered 23,470 not including over 5000 requests for information by telephone. Searches and translations were 202 and 221, respectively, while 3637 individuals were supplied with photoprints. By various methods, a total of 37,000 members was served. The main collection totals over 130,000 volumes, pamphlets, maps, etc., including about 8300 additions during the year. The record of the rental collection shows 317 members borrowed books. Receipts from the sale of books from the duplicate collection amounted to $1062.83.

A study by the Trustees of operating cost resulted in the recommendation to the Founder Societies of a distribution by which the expense is partially shared upon a per capita basis. This method was approved by the Founders.

The amount appropriated for operating expense for the year was $46,300. The operating cost was $45,584.10. The Service Bureau met its expenses from its receipts.

The complete report in pamphlet form may be obtained by addressing Harrison W. Craver, Director, Engineering Societies Library, 33 West 39th Street, New York, N. Y.

1929 Officers of Eye Sight Convervation Council of America

Lawrence W. Wallace has been re-elected president of the Eye Sight Conservation Council of America, which is conducting a nationwide movement for better vision in industry and education. Mr. Wallace is Executive Secretary of the American Engineering Council, and a Past-President of the Society of Industrial Engineers. Other officers for 1929 have been chosen as follows: Vice-President, Bailey B. Burritt, New York;

General Director, Guy A. Henry, New York; Treasurer, William R. Wall, New York. James J. Davis, Secretary of Labor, was named a member of the Board of Councilors. The following were also elected to the Board: Dr. Arthur L. Day, Director of the Geophysical Laboratories of the Carnegie Institution of Washington; Prof. Charles H. Judd, Director of the School of Education, University of Chicago; Dr. Frederick B. Robinson, President of the College of the City of New York; Prof. Joseph W. Roe, head of Industrial Engineering Department of New York University, G. E. Sanford, Schenectady, New York, past president of the American Society of Safety Engineers; Richard E. Simpson, Associate of the Institute and research engineer of Hartford, Conn.; Dr. John J. Tigert, former U. S. Commissioner of Education; Dr. Thomas D. Wood, Teachers College, Columbia University.

Dr. F. C. Caldwell, a Fellow of the Institute, and professor of electrical engineering at Ohio State University, and Dr. Morton G. Lloyd of Washington, chief of the Safety Section, U. S. Bureau of Standards and also a Fellow of the Institute, were elected to the Board of Directors.

The Hoover Committee on Elimination of Waste in Industry attributed heavy industrial losses to defective eyesight of workers. The Eye Sight Conservation Council cooperated with the Committee, and has carried on extensive research in this field.

Special Courses at Carnegie Institute

Courses for teachers of electricity and industrial education will be given during a six weeks' period between June 28 and August 9, 1929 at the Twelfth Summer Session of the Carnegie Institute of Technology in Pittsburgh, according to an announcement from Dr. Roscoe M. Ihrig, director of summer courses. The courses will be given under the supervision of the Department of Electrical Engineering; and although, as the announcement indicates the courses in electricity are outlined primarily for teachers and supervisors, the work is also designed to have a special appeal to undergraduates and those who desire higher technical training. Courses available include Principles of Electricity, Elementary Electric Wiring, and Advanced Electric Wiring. Also, the College of Industries, will give courses in Welding, and the college of Engineering will give various subjects under Chemistry, Physics, Mechanics, Surveying, and Engineering Drawing.

ENGINEERING FOUNDATION

ANNUAL REPORT

The Annual Report of Engineering Foundation for the year ending February 21, 1929, the fourteenth year of its existence, has just been issued. The following is an extract from opening paragraphs and a summary of the financial statement. The complete report can be obtained by addressing Engineering Foundation, 29 West 39th St., New York, N. Y.

"Experience is showing year after year the actual usefulness and the much greater possibilities of the joint research organization of our four senior national engineering societies with their 60,000 members. Even with small and uncertain resources, many members of these societies on special research committees are making valuable contributions of knowledge for the betterment of engineering and industrial practises. The engineer's studies must include the effects of his technical activities upon his fellow humans and their social organization. A science of humanics should be built up by research.

During the year, the Foundation continued its aid to researches concerned with arch dams, concrete arches, steel columns for bridges and buildings, blast furnace slags, electrical insulation, lubrication, engineering education and painting of wood. Much energy was devoted, besides, to preliminary inquiries and other preparations for two large new research projects: alloys of iron and wire ropes.

CONDENSED FINANCIAL STATEMENT
Calendar Year 1928

Resources		
Balance January 1, 1928		
Temporary investments, Government securities	$28,303.38	
Cash	3,491.67	$31,795.05
Receipts—Summary		
Income from endowment and temporary investments	$31,075.73	
Income from sale of publications	453.98	
Loss by maturity of U. S. 3rd Liberty bonds	3.06	31,526.65
Total resources		$63,321.70
Expenditures—Summary		
Research projects	$18,751.30	
Promotion of Research	7,640.00	
Administrative expenses	3,565.00	
Total for furtherance and support of research		$29,956.30
Balance January 1, 1929		$33,365.40

PERSONAL MENTION

Ernest V. Pannell, Consulting Electrical and Metallurgical Engineer, is now occupying offices in the Chanin Building, 122 East 42nd Street, New York, N. Y.

E. F. Whitney, manager of the Portland office of the General Electric Company since 1923 has been appointed Assistant Manager of the East Central District with headquarters at Cleveland.

Walter W. Meiers has resigned from the position of Assistant Engineer with the N. Y. Central Railroad, New York City to become Power Engineer with the B. F. Goodrich Rubber Co., Akron, Ohio.

John E. Yarmack, formerly of the Victor Talking Machine Company, is now with the firm of Foote, Pierson & Co., Inc., as Chief Engineer and Superintendent. The firm, which has been in New York City since its inception now moves into a new plant located at 75 Hudson Street, Newark, N. J.

J. B. Clapp, who prior to March 1 was associated with the Public Service Electric and Gas Company's Distribution Department, Newark, New Jersey, is now with the Copperweld Steel Company, as Sales Engineer in charge of the New York Office at 50 Church St.

William N. Reinhard, recently of the Lower St. Lawrence Power Company of Rimonski, Quebec, in the capacity of Chief Engineer, has become the United States representative of the T. D. Berry Co., Ltd., manufacturers and distributors of an instrument for live line testing of transmission line insulators.

E. Herzog has resigned from his position as Research Engineer of the General Electric Company, West Lynn, Mass., to become Electrical Testing Engineer with the State Line Generating Company at Hammond, Ind., in charge of the Electrical Testing Section of the Operating Department.

J. C. Lincoln, formerly President of the Lincoln Electric Company, Cleveland, has been elevated to the position of Chairman of its Board of Directors. Mr. J. F. Lincoln, formerly Vice-President and since 1912 an outstanding figure in the electrical industry, and among the first to envision the enormous potentialities of electric arc welding, now becomes President.

William J. Lewis, Jr., member of the Van Rensselaer H. Greene management organization, has been transferred to

Rochester as its Secretary and General Manager and a Director of the Rochester Ice & Cold Storage Utilities, Inc., which owns and operates four ice plants and three cold storage warehouses, all electrically driven in the city of Rochester and a 12,000-ton Natural Ice property at Conesus Lake.

WALTER ROLAND ROXBURY, who for three years was Specification Engineer with the New York Rapid Transit and later Coordination and Specification Engineer in the Bureau of Equipment and Operation of the Board of Transportation, has recently resigned from the later organization to accept a position as Electrical Engineer of the New Yorker Hotel Corporation to supervise the installation of the entire isolated plant, auxiliaries and associated systems.

Obituary

S izo Misaki, who was elected to membership in the Institute in December 1899 when he was chief engineer and superintendent for the Hanshin Electric Railroad Company, Kotee, Japan, died at his home at Ashiya, near Kobe, February 23, 1929, after a brief illness of only a few days. Born at Hiogo Gen, Japan, July 1867, Mr. Misaki was educated in the common and high schools there, and after his graduation, served a year as a teacher. Subsequent education was in a private, higher school at Tokyo. In 1887 he learned English in grammar-school at San Francisco and later in the boys' high school. In 1891-92 he was a student at the Stanford University and was graduated from the Electrical Department of Purdue University in 1894. He then entered the engineers office of the Miyoshi Electric Works, Tokyo, and was also consulting engineer for the Kitano Electric & Mfg Co., Osake, Japan. From 1895 to 1899 he acted as popular consulting engineer at Tokyo designing several large plants and machinery,—in fact, almost all the newer type of machinery manufactured by the Miyoshi Electric Works was of his design. While still a resident of Japan, Mr. Misaki made short trips to the United States to study electrical progress, especially with regard to railroading. Immediately prior to his death his court standing was raised to the sixth rank, junior grade in recognition of his services to the State.

William Nelson Motter, who has been prominently identified with the Allis-Chalmers Manufacturing Company, died March 9 at Milwaukee, Wis., at the age of 55. Mr. Motter joined the Institute in 1910 as an Associate and was made a Fellow in 1912. After teaching for two years at Purdue University, from which he graduated in 1896 with honors, he began his engineering career. For the last twenty years he has engaged in the design of direct-current machinery for the Allis-Chalmers organization; that for the exposition at San Francisco in 1915 was also designed and installed by Mr. Motter, as well as that for similar projects at Niagara Falls and Philadelphia. He was a member of the Milwaukee Engineering Society, Milwaukee, Wisconsin, which has been his city of residence for some time.

Valere A. Fynn, nationally known consulting engineer and inventor, a member of the Institute since 1909 and a Fellow since 1912, died March 20 at St. Luke's Hospital, St. Louis, Mo. He was 58 years of age. Born in Russia, when his father, Irish by birth, was building the imperial railroads there, he received his technical education at the Swiss Federal Polytechnic, Zurich. His practical engineering experience was obtained with Brown Boveri & Company, Switzerland, and with Easton, Anderson & Golden in London. He subsequently established his own consulting engineering offices in London. Perhaps his greatest achievement was his contribution to the development of the single-phase motor and other inventions relating to motors, among which the Fynn-Weichsel motor is outstanding. In 1905 he published his solution of the problem of speed regulation of single-phase motors following a long series of inventions in this field, the development of a number of new motors and the improvement of types already existent; in fact, Mr. Fynn had come to be recognized as an authority on patent matters and had over 300 patents to his credit in nine different countries. His single-phase motors were manufactured by the Elektricitäts-Gesellschaft Alioth of Switzerland, France, Germany, Italy and Spain and the General Electric Company of England. In 1909 he transferred his interests to the United States, and from that year until 1921 he was consulting engineer for the Wagner Electric, which took out licenses under almost all of his numerous patents. During the twelve years of his affiliation with this Company, Mr. Fynn gave it his almost undivided attention, but since 1921 he has been engaged in an independent consulting engineering service, with offices in St. Louis, Missouri. He was a member of the Institution of Electrical Engineers, London and was an enthusiastic outdoor man, holding membership in the Alpine Club (London) the Swiss Alpine, the Academical Alpine (Zurich), the American Alpine, the Canadian Alpine, the French Alpine, Italian Alpine and the Racquet of St. Louis. His is one of the oldest families of Galway County, Ireland. His contributions to technical literature are, "A Single-Phase Commutator Motor," "Torque Conditions in Alternating-Current Motors," "The Design of Direct-Current Machinery," "Characteristics of the Asynchronous Single-Phase Shunt Induction Generator with Self-Excitation," "A Contribution to the Theory of the Single-PhaseInduction Motor," "The Classification of Alternating-Current Motors," "No-Load Conditions in Self-Excited Single-Phase Shunt Induction Motors," "Factors Affecting the Design of Self-Excited Single-Phase Shunt Induction Motors," "A New Self-Excited Synchronous Induction Motor," "Another Form of Self-Excited Synchronous Induction Motor," "A New Separally Excited Synchronous Induction Motor." Many of which were presented before the membership of the Institute at its various conventions.

A. I. E. E. Section Activities

FUTURE SECTION MEETINGS

Cleveland

Annual Dinner Meeting. Speaker: R. F. Schuchardt, President, A. I. E. E., Electric League Rooms, Hotel Statler, May 23.

Columbus

Power Supply for Railway Signals and Automatic Train Control, by C. F. King, Jr., Westinghouse Electric & Mfg. Co. Afternoon session, 2:30 p. m., Ohio Power Co. Building, Newark, Ohio. Inspection of Pennsylvania Railroad automatic train control substation in Newark. Evening session, 6:30 p. m. Chittenden Hotel, Columbus. Ladies Night. Election of officers. May 24.

Detroit-Ann Arbor

Overhead Line Research. Ann Arbor, May 21.

Lehigh Valley

Power Transmission, by A. O. Austin, Ohio Insulator Co. Inspection of Hazleton Service Depot. Altamont Hotel, Hazleton. May 10-11.

Madison

Election of Officers and showing of Baron Shiba's high speed film. May 22.

Niagara Frontier

The Cascade Tunnel, by J. B. Cox, General Electric Co. Election of officers. May 24.

Pittsburgh

Ladies Night. Meeting and Dinner Dance. May 14.

St. Louis

May 15.
June 19.

Seattle

Competitive Papers. May 21.

Sharon

Communism, by Capt. J. R. O'Brien. Banquet Meeting. June 4.

Toronto

Ladies Night. Election of Officers. May 10.

Utah

Joint meeting with University of Utah Branch. May 13.

Vancouver

Annual Dinner. June 4.

Washington

High-Capacity Mercury Arc Rectifiers, by F. A. Faron, General Electric Co. May 14.

NEW YORK SECTION

Expansion of Activities

As announced in the April issue of the JOURNAL, the New York Section has recently had under consideration a considerable expansion of its activities, including the organization of several groups for the purpose of carrying on activities that are deemed of particular interest to such groups. The "Power Group" has already organized and it held a meeting on the evening of April 10 as reported below.

At a meeting of the Executive Committee of the Section held on April 3 the following plan "for expanding the activities of the New York Section" was adopted:

WHEREAS, Sec. 26 of the By-laws of the New York Section state that "in order to provide for the proper handling of the Section's routine work and the management of its affairs, the Executive Committee may adopt in connection with these By-laws such rules and regulations as may be found necessary; but no rule or regulation shall be adopted which will conflict with these By-laws or with the Constitution and By-laws of the Institute;" and

WHEREAS, it appears desirable to expand the activities of the New York Section in order to provide opportunities for greater participation by the membership, particularly the younger group, in its various activities, both technical and administrative; and

WHEREAS, this matter has been considered by special committees of the New York Section, which, after careful consideration, have made various recommendations as outlined below; therefore

RESOLVED: That the following regulations be hereby adopted, to take effect immediately:

TECHNICAL GROUPS

Organization. Technical Groups shall be organized for the purpose of conducting meetings and carrying on other activities that are deemed of particular interest to such groups, but open to the entire membership of the Section, for example

A Power Group
A Transportation Group
A Communication Group

(The Power Group has already organized and has elected temporary officers to serve until there is an election of officers whose terms will begin August 1, 1929.)

Whenever there appears to be a desire on the part of the membership to organize a new Group, the chairman of the Section shall appoint a special committee to investigate the matter and report its recommendations to the Executive Committee of the Section. If a decision is made to organize a Group, the chairman of the Section shall then appoint an Organizing Committee, which shall be responsible for making the proposed plan known to the membership of the Section, and shall arrange for and conduct an election of temporary officers to serve until the next regular election.

Officers and Executive Committee. The Officers of each Group shall include a chairman, a vice-chairman, and a secretary; and the Executive Committee, which shall be responsible for all activities of the Group, shall consist of these three officers, and such other members as they shall elect.

Election of Officers. Each year, prior to March 1, the chairman of each group shall appoint a Nominating Committee, which shall report its recommendations regarding the nomination of officers to the first meeting of the group held after March 15, at which meeting other members in addition to those named by the Nominating Committee may be added to the list of nominees by a majority vote of the meeting; and at the next meeting of the Group, officers shall be elected from this list of nominees, by majority vote of the members of the New York Section present, for the term of one year beginning on the following first day of August, and thereafter until their successors are elected.

Committees. The chairman of the Group shall appoint such committees as may be deemed desirable to carry on the meetings, or other activities subject to the approval of the Group Executive Committee.

Ex-Officio Membership on various Committees of the Section The Chairman of each Group shall be a member, ex-officio, of the Finance Committee of the Section, thus providing for the necessary coordination in connection with the financing of all Group activities.

The chairman of each Group Committee shall be a member, ex-officio of the corresponding committee of the Section.

Relations with Institute Headquarters. The relations between the New York Section and the National Headquarters in New York are in general identical with the relations between the other Sections and Headquarters; but the New York Section, in accordance with arrangements made with the National Secretary, may have the advantage, if desired, of the use of the facilities of the mailing department maintained at Headquarters, including the addressograph stencils for the entire New York Section membership. (Separate mailing lists for the different Groups will not be maintained.) A proper charge against the funds available for the New York Section will be made for this service.

Reports. Reports of all Group activities shall be made by the secretary of each Group to the secretary of the New York Section, who, in turn will make reports to the National Secretary, as required by Sec. 58 of the Institute Constitution.

As a step in carrying out this plan the Executive Committee deemed it desirable to provide for the expansion of the standing committees of the Section and accordingly, a proposed amendment to the By-laws was approved by the Executive Committee and a copy of the proposed amendment was mailed to all the members of the Section accompanied by a notice that the proposed amendment would be voted upon at the next meeting of the Section on April 26.

The amendment provides for five standing committees, in addition to the Executive committee, as follows: (1) Program; (2) Entertainment; (3) Membership; (4) Finance; (5) Publicity.

CONTACTS BETWEEN ENGINEERS AND THE PUBLIC DISCUSSED BY THE TORONTO SECTION

At a meeting of the Toronto Section held on March 8, 1929, E. M. Ashworth, Gen. Mgr., Toronto Hydro-Electric System, presented a paper entitled *The Electrical Engineer and the Public*, in which he discussed the natural tendencies of engineers toward concrete and physical ideas and away from the metaphysical and abstract, with an inclination toward repression of visionary tendencies. Methods by which engineers can serve the public were mentioned.

Important contributions to the discussion of this subject were made by Chairman E. M. Wood, Vice-President, A. B. Cooper, W. P. Dobson, A. E. Davison, C. E. Sisson, H. C. Powell, and Wills MacLachlan, all of whom emphasized the importance of wider contacts between engineers and others.

President R. F. Schuchardt urged that engineers serve the public through the dissemination of the specialized information with which they are so familiar. As specific instances in which they might be of real service, he mentioned traffic, zoning, conservation of beauty spots, presentation of humanistic aspects of engineering, contacts with students and recent graduates, etc.

Efforts of the University of Toronto to develop the cultural side of the students were summarized by Professor H. W. Price. Attendance 82.

JOINT SECTION AND BRANCH MEETING IN CLEVELAND

The second annual Joint Meeting of the Cleveland Section and the Case School of Applied Science Branch was held in the Electrical Building, Case School of Applied Science, on March 19th, 1929. The dinner preceding the program was attended by eighty persons and was made especially interesting by informal introductions by Professor H. B. Dates, the first Chairman of the Cleveland Section, of seven other Past Chairmen, Mr. Henderson the present Chairman, and several guests.

The program, which was arranged for by the officers of the Case School of Applied Science Branch, was as follows:

Welcome, W. A. Thomas, Chairman, Case School of Applied Science Branch.

Address, E. W. Henderson, Chairman, Cleveland Section, A. I. E. E.

Activities of the Case Branch, W. A. Thomas, Chairman, Case School of Applied Science Branch.

Address, J. L. Beaver, Vice-President, Middle Eastern District, A. I. E. E.

The Motor Coach in Urban Transportation, L. W. Bale, Member, Case School of Applied Science Branch.

The Failure of Our Present Definition of Capacity, R. W. Schindler, Member, Case School of Applied Science Branch.

The Student Branch as a Part of the Institute Organization, H. H. Henline, Assistant National Secretary, A. I. E. E.

After the program, at which the attendance was about 125, all the laboratories were open for inspection, and all present enjoyed this opportunity to become better acquainted with the work done by the electrical engineering department as well as to engage in informal discussion.

JOINT SECTION AND BRANCH MEETING AT MILWAUKEE

The Milwaukee Section and the Student Branches at Marquette University and the School of Engineering of Milwaukee held a joint meeting at the School of Engineering on March 6, 1929, and participated in a symposium on the subject *What does the College Graduate Expect of Industry and What does the Industry Expect of Him?*

The students' side of the subject was presented by the following men who were chosen by competition in their Branches:

J. Hahn, Marquette University
Henry Haase, Marquette University
George Henkel, School of Engineering of Milwaukee

The industrial aspects were presented by the following local engineers:

H. S. Day, Wisconsin Telephone Co.
E. G. Peterson, Cutler-Hammer Mfg. Co.
W. J. McCarter, Milwaukee Elec. Ry. & Lt. Co.

President R. F. Schuchardt closed the program with a summary of the talks mentioned above.

The Section announced the establishment of two prizes for student papers presented in the Milwaukee territory by May 2, 1929; a first prize of $25.00 and suitable medal, and a second prize of $10.00 and medal. The attendance was 76.

RECENT NEW YORK SECTION MEETINGS

New Developments in Electrothermics and Electrochemistry. On the evening of Friday, March 22nd, the New York Section had as a speaker, Dr. Colin G. Fink of Columbia University. Dr. Fink gave a very interesting review of recent progress in electrochemistry and electrothermics, touching upon the developments in the electric furnace industries; in steel, the ferro-alloys; the growth of aluminum and the new beryllium. Methods of combating corrosion; the use of chromium; the electrochemistry of gases. The talk was illustrated with many slides and exhibits of articles now being manufactured as a result of the progress described. Dr. Fink closed his talk with a description of the work he is doing for the museums of New York in the restoration of ancient bronzes.

Power Group Meeting. On April 10 the first meeting of the newly organized "Power Group of the New York Section" was held. The new plan of increased New York Section activities is described in detail elsewhere. The meeting was held in Engineering Societies Building. George Sutherland, temporary chairman of the Power Group presided and opened the meeting by calling on Chairman Tapscott of the New York Section who outlined the new plan of group activities. The first scheduled speaker, L. G. Colson of the United Electric Light and Power Company gave a talk on the "Proposed Vertical Network Distribution Plan for Serving the Chrysler Building." He was followed by J. M. Comly of the Brooklyn Edison Company who described the "Design Features of Network Equipment Used in Brooklyn—Relation between Large Customer Services and Network System—Network Voltage Regulation." Both talks were illustrated. Considerable discussion then followed on both presentations. There was an unexpectedly large attendance, over 350 members and guests being present.

PAST SECTION MEETINGS

Akron

Modern Power Plant Design and Some Possibilities in High-Pressure Applications in the Future, by E. H. McFarland, Mgr., Philo Plant, Ohio Power Co. Talk by Prof. J. L. Beaver, Vice-President, Middle Eastern District, A. I. E. E., on his recent trip to England and the Continent. At a dinner preceding the program Prof. Beaver gave a short talk on the activities of the Institute. Joint meeting with Akron Section, A. S. M. E. March 8. Attendance 84.

Baltimore

Welding of Steel Bridges and Buildings, by F. P. McKibben, Consulting Engr. Illustrated. Baltimore Section, A. I. E. E. invited to meet with A. S. C. E. Section and the Engineers' Club of Baltimore. October 26. Attendance 50.

Inspection trip to Steel Plant, Sparrows Point. Joint with A. S. M. E. and the Baltimore Engineers' Club. November 9. Attendance 250.

High Tension Insulators, by D. H. Rowland, Research Engr., Locke Insulator Corp. Inspection trip to Plant of Locke Insulator Corp. was held prior to the meeting. Refreshments served. November 16. Attendance 150.

The Development of Lighter-Than-Air Ships, by W. W. Pagon. January 10. Attendance 95.

Diesel Electric Drive, by H. C. Coleman, Mgr., Marine Engg., Westinghouse Elec. & Mfg. Co. March 1. Attendance 95.

Electrical Eyes and Their Use in Communication, by John Mills, Director of Publication, Bell Telephone Laboratories. A. S. M. E., I. E. S., and Engineers' Club invited to participate. March 15. Attendance 205.

Cleveland

Joint meeting with the Case School of Applied Science Branch. See more complete report in Student Activities Dept. March 19. Attendance 125.

Cincinnati

Human Reactions to Light (with demonstrations), by Sam Freeman, Director, Lighting Bureau, The Union Gas & Electric Co. (Illustrated). D. J. Finn, Edison Lamp Works, General Electric Co., made an announcement regarding Lights Golden Jubilee Year. April 11. Attendance 46.

Connecticut

Mastery of Lightning, by F. W. Peek, Consulting Engr., General Electric Co. Bridgeport, March 5. Attendance 200.

Engineering Education, by Prof. C. F. Scott, Yale University, Slides.

Machine Tools—The Conquerors of One Thousandth of an Inch and One Second of Time, by L. D. Burlingame, Brown & Sharpe Mfg. Co. Slides. 74th meeting, joint with Waterbury Section, A. S. M. E., preceded by a dinner. March 21. Attendance 60.

Dallas

The Physical and Psychological Principles Underlying Television, by Dr. J. O. Perrine, Engr., Information Dept., American Tel. & Tel. Co. Slides and demonstrations. March 27. Attendance 343.

Denver

Social meeting arranged by the Ladies Entertainment Committee. Dinner followed by a card party. March 14. Attendance 74.

Detroit-Ann Arbor

Recent Developments in Speech Transmission, by S. P. Grace, Assistant Vice-President, Bell Telephone Laboratories, Inc. Demonstrations. Joint meeting with Detroit Engineering Society, preceded by a dinner. J. J. Shoemaker, Chairman, Membership Committee, reported upon the work of the Committee and announced the appointment of a special Graduates Follow-Up Committee of the Membership Committee. March 15. Attendance 250.

Erie

Welding, by D. H. Deyoe, General Electric Co., Schenectady, and R. C. Marthens, Westinghouse Electric & Mfg. Co. Slides. March 19. Attendance 140.

Fort Wayne

Gaseous Discharges and Hot Cathode Neon Tubes, by C. G. Found, Research Laboratory, General Electric Co. Slides and demonstrations. Motion pictures shown before and refreshments served after the meeting. March 21. Attendance 50.

Houston

The Physical and Psychological Principles Underlying Television, by Dr. J. O. Perrine, American Tel. & Tel. Co. March 29. Attendance 250.

Kansas City

Physical and Psychological Principles Underlying Television, by Dr. J. O. Perrine, American Tel. & Tel. Co. Demonstrations and slides. Brief talks by A. E. Bettis, Director, A. I. E. E., and C. A. Ulffers, General Mgr., Southwestern Bel Tel. Co. Vice-President B. D. Hull gave a brief talk and announced the Regional Meeting to be held in Dallas, May 7-9. March 25. Attendance 300.

Lehigh Valley

What's Going on in Anthracite, by R. C. Haines, Executive Secretary, Anthracite Cooperative Association, and

Making Sound Visible and Light Audible, by John B. Taylor, Consulting Engr., General Electric Co. Slides and demonstrations. Wilkes-Barre, March 22. Attendance 161.

Louisville

Narrowcasting, by J. B. Taylor, Consulting Engr., General Electric Co. Illustrated, demonstrations. Address on planning and zoning in other cities and contemplated developments in Louiville, by Harland Bartholomew, Consulting Engr., St. Louis, recently selected as Engineer for the City Planning & Zoning Commission of Louisville. Engineers & Architects Club and Louisville Section, A. S. M. E., invited to attend. March 19. Attendance 112.

Lynn

Transatlantic Telephone Circuits, by D. W. Gilman, New England Tel. & Tel. Co., Northern Area. Illustrated lecture. Motion picture, entitled "Driving the Longest Railroad Tunnel in the Western Hemisphere." March 20. Attendance 127.

The Challenge of the New Day, by David Vaughan, Professor of Social Ethics, Boston University. Light entertainment after address. March 30. Attendance 279.

Madison

Carrier Telephone Systems, by H. R. Huntley, Transmission Engr., Wisconsin Telephone Co. Slides. March 20. Attendance 75.

Milwaukee

Telephone Repeaters, by O. F. Wallman, Wisconsin Telephone Co., and

Carrier Telephone System, by H. R. Huntley, Transmission Engr., Wisconsin Telephone Co. November 7.

Electrically Welded Steel Structures, by F. P. McKibben, Consulting Engr., General Electric Co. Meeting held with Milwaukee Engineering Society, preceded by a dinner. November 21. Attendance 165.

Power Factor and Means for Its Improvement, by S. H. Mortensen, Allis-Chalmers Mfg. Co. Slides. December 5. Attendance 53.

Application of Modern Illumination to Business, by I. L. Illing, Illuminating Engr., Milwaukee Electric Railway and Light Co. Demonstrations. January 9. Attendance 70.

The Photo-Electric Cell and Its Uses in Communication, by Dr. J. O. Perrine, American Tel. & Tel. Co. Demonstrations of talking moving pictures. February 18. Attendance 225.

Symposium on subject "What Does the College Graduate Expect of Industry and What Does the Industry Expect of Him?" See more complete report elsewhere in Section Activities Dept. March 6. Attendance 76.

Minnesota

Recent Research Development, by C. E. Skinner, Asst. Director of Engineering, Westinghouse Elec. & Mfg. Co. Demonstrations. Dinner preceded the meeting, held jointly with Minneapolis Engineers Club, St. Paul Engineers Society, A. S. M. E. Sections, and University of Minnesota Branch, A. I. E. E. March 11. Attendance 175.

Nebraska

Outstanding Achievements of Research Work in the General Electric Company, by H. D. Sanborn, General Electric Co., Chicago. Motion picture "Beyond the Microscope." Reading of general letter dated March 9, 1929, on subject "Appreciation of the Engineering Profession;" reading of President R. F. Schuchardt's message in March JOURNAL. Nominating committee appointed. L. F. Wood, Secretary, chosen as Section Delegate to Summer Convention. March 28. Attendance 30.

Niagara Frontier

Experiences with the White Indians of Darien, by R. O. Marsh, Research Engr., Dupont Rayon Co. Maps and slides. Music. Dinner preceded the meeting. A. I. E. E. Ladies Night. January 18. Attendance 40.

Oklahoma

The Engineer in the Public Utility, by H. S. Thompson, Consulting Engr., Oklahoma City. Short talk by Dean Felgar, University of Oklahoma, on some of the educational problems in engineering. Dean Phillip S. Donnell, Oklahoma A. & M. College, gave a brief talk. Prof. F. G. Tappan, University of Oklahoma, made an announcement regarding Regional Meeting to be held in Dallas, May 7-9, March 12. Attendance 60.

Philadelphia

Joint meeting with Student Convention. See page 330 of April JOURNAL for complete report. March 11. Attendance 205.

Measurement of the Effects of Lightning on Transmission Lines, by E. S. Lee, General Engineering Laboratory, General Electric Co. Illustrated with slides and moving pictures. Dinner preceded the meeting. April 8. Attendance 108.

Pittsburgh

Long Distance Toll Cable Transmission, by J. A. Cadwallader, Engr. of Transmission & Outside Plant, The Bell Telephone Co. of Pa. Joint with Electrical Section, Engineers Society of Western Pa. March 12. Attendance 101.

Portland

Fifty Years Progress in Bridge Building, by Dr. Steinman of Steinman & Robinson, Consulting Engineers. Joint meeting of all engineering societies. March 8. Attendance 130.

Recent Research Developments of the Westinghouse Electric & Manufacturing Company, by C. E. Skinner, Assistant Director of Engineering. March 21. Attendance 120.

Rochester

Progress of X-Ray in Medicine, Research, and Industry, by E. C. Jerman, Director, Educational Dept., Victor X-Ray Corp. Slides. Joint meeting with Rochester Engineering Society and Rochester Section, I. R. E., preceded by a dinner. March 15. Attendance 77.

St. Louis

Electric Call System, by W. F. Callahan, Western Union Telegraph Co. Slides. Nominating Committee elected. Attendance prizes awarded to Elmer Aschemeyer, H. Norman Chapman, Jr., Geo. R. Thatcher, W. R. Waller, E. G. McLagan, and G. A. Waters. March 20. Attendance 65.

San Francisco

The Electrical Breakdown of Gases at Atmospheric Pressure, by Dr. L. E. Loeb, University of California. Local members, American Chemical Society, invited. Dinner preceded meeting. Entertainment provided by three students of University of California. March 1. Attendance 140.

Schenectady

The Transformer for Superpower Transmission and Distribution, by H. O. Stephens, General Transformer Engg. Dept., General Electric Co., Pittsfield. January 25. Attendance 150.

High Tension Underground Cable Research and Development, by G. B. Shanklin and G. M. McKay, General Electric Co.;

Line-Start Induction Motors, by C. J. Koch, General Electric Co., and

Telemetering, by C. H. Linder, C. E. Stewart, H. B. Rex, and A. S. Fitzgerald, General Electric Co. The above papers were presented at the A. I. E. E. Winter Convention. February 1. Attendance 200.

Latest Developments in Traffic Control, by J. G. Regan, Central Station Dept., General Electric Co. February 15. Attendance 200.

Modern Engineering Economics, by Dean D. S. Kimball, Dean of the College of Engineering, Cornell University. March 8. Attendance 400.

Seattle

The National Engineering Societies and Their Cooperation in National and International Matters, by C. E. Skinner, Assistant Director of Engineering, Westinghouse Electric & Mfg. Co. Annual joint meeting of local sections of the four Founder Societies. Dinner preceded the meeting, with musical program and addresses by C. E. Skinner, Lieut. Col. H. C. Fiske, R. H. G. Edmonds and George W. Evans March 19. Attendance 170.

Spokane

Recent Research Development of the Westinghouse Electric & Manufacturing Company, by C. E. Skinner, Asst. Director of Engineering of that Company. March 15. Attendance 29.

Springfield

Activities of Underwriters' Laboratories, by G. B. Muldaur, General Agent, Underwriters' Laboratories. Nominating committee appointed. March 11. Attendance 38.

Syracuse

General Principles of Power Plant Construction, by V. E. Alden, Mechanical Engr., Stone & Webster Engg. Corp. Joint with A. S. M. E. Nomination of officers for next year announced. April 8. Attendance 162.

Toronto

The Electrical Engineer and the Public, by E. M. Ashworth, General Mgr., Toronto Hydro-Electric System. See report elsewhere in Section Activities Dept. March 8. Attendance 82.

Teletype, by F. Knight, Bell Telephone Co., Montreal. March 2. Attendance 101.

Utah

Manufacture of Insulators, by G. L. Wilder, District Mgr., Locke Insulator Co. Moving picture. John Salberg reelected representative on Governing Board, Engineering Council of Utah. March 18. Attendance 55.

Washington

Lightning and Lightning Protection, by J. H. Cox, Transmission Engr., Westinghouse Electric & Mfg. Co. Dinner preceded the meeting. March 12. Attendance 130.

A. I. E. E. Student Activities

CONFERENCE ON STUDENT ACTIVITIES IN DISTRICT NO. 2

In addition to the student activities program on Thursday morning, of which an account is included in the report on the Cincinnati Regional Meeting, elsewhere in this issue, the Counselors and Student Delegates met separately for luncheon on Wednesday and met together for luncheon on Thursday. All plans for these Conferences were made by the District Committee on Student Activities, of which Professor F. C. Caldwell, Counselor of Ohio State University Branch, is Chairman, in cooperation with the Regional Meeting Committee.

Of the eighteen Branches in the Middle Eastern District, 13 were represented by both Counselors and Student Delegates and two others by students only. Each of the Student Delegates presented during the Thursday morning session a two-minute report on some activity of his Branch. The principal parts of the report of R. B. McIntosh, Chairman-elect, Case School of Applied Science Branch, for which he received the first prize of $10.00, are quoted below.

"About this time, last year, the Student Branch of the A. I. E. E. at Case School of Applied Science invited the members of the Cleveland Section to meet with them in a joint meeting.

"The arrangements for the meeting were made entirely by the Branch, and the major part of the program was presented by the students. An effort was made to make the meeting entertaining as well as instructive.

"The Case Chairman presided at the meeting and welcomed the visitors. Two students presented papers of an original nature, one of which was illustrated by a motion picture film. The entertainment highlight of the evening was a comedy skit, written and played by two students who possessed unusual dramatic ability. After the meeting the visitors inspected the laboratories with the aid of student guides.

"This joint meeting met with such instantaneous success and provoked such sincere praise from the Section that a second joint meeting was warranted. It was held on Tuesday of this week. A similar program was carried through, and I am sure it was as successful as its predecessor.

"We, at Case School, feel that these meetings are quite beneficial to both the students and members of the local Section. They afford an opportunity for the students to become acquainted with engineers who are out in industry. The students can learn from them what will be demanded after graduation. On the other hand, these meetings allow the Section to become familiar with the course of instruction at Case School, and thereby gage what they can expect from a Case School graduate.

"These two meetings have proven the experiment to be sound. They have passed from the experimental stage to become an annual institution in engineering circles in Cleveland."

Luncheon Meetings

At the luncheon of Counselors and others interested on Wednesday, Professor Caldwell outlined the principal problems of the District Committee on Student Activities, as including the finding of methods to extend the interest, enthusiasm, and acquaintance of those in the work, the passing on of good ideas, serving as advisors to the A. I. E. E. in student matters, and especially the encouragement of students in the presentation of papers. Professor J. L. Beaver, Vice-President, District No. 2, and Chairman of the Committee on Student Branches, gave a summary of Branch activities and problems, in which he emphasized the importance of active participation by the students and mentioned various methods of increasing their activity, such as talks on summer employment, abstracts of published papers, reports on thesis work, debates, prizes, and the choice of good officers.

The Thursday luncheon meeting was attended by Counselors, Student Delegates, and a number of Institute officers and others interested. There was discussion of the various reasons which prevent young men from becoming Associates immediately after the expiration of their period of Student enrolment. Professor

Caldwell, who will represent the District Committee on Student Activities at the Summer Convention, was instructed to take to the Conference of Officers and Delegates the desire of his Committee that some step be taken to bridge the gap between the expiration of Student enrolment and admission as Associates, and thus encourage a larger number to make their connections with the Institute continuous.

Professor H. E. Dyche, Counselor, University of Pittsburgh Branch, was elected Chairman and Professor Morland King, Counselor, Lafayette College Branch, was elected Vice-Chairman of the District Committee on Student Activities for the year beginning August 1, 1929.

ELECTRICAL SHOW AT MICHIGAN STATE COLLEGE

During Farmers' Week at Michigan State College, February 4-8, the Student Branch of the Institute provided an Electrical Show having for its aims the education of the rural classes in the uses of the more common electrical phenomena and the entertainment and instruction of people especially interested in electricity. In view of these purposes the experiments and exhibits covered a wide range from the fundamental principles of the motor, generator, and transformer to television apparatus and the operation of induction furnaces. The laboratories were in full operation, showing exactly the nature of the work done by the students during the school year. It has been the custom of the Branch in the past to hold the show for three days during Farmers' Week, but this year it was held open on the fourth day, at the request of the State Board of Agriculture. The attendance was estimated at from 8000 to 8500.

CONFERENCE ON STUDENT ACTIVITIES IN DISTRICT NO. 6

The Third Annual Conference on Student Activities of the North Central District was held at the University of South Dakota on March 8 and 9, 1929. Six of the eight Branches in the District were represented by both Counselors and Chairmen, and another was represented by the Chairman only. Dean O. J. Ferguson, Vice-President, District No. 6, and Professor O. E. Edison, Secretary of the District, were present.

Friday Evening Session

The first session was held on Friday evening, March 8, Vice-President O. J. Ferguson presiding, and the following program was presented:

Transmission of Pictures by Wire, S. B. Hughes, Transmission Engineer, Northwestern Bell Telephone Co.

Address of Welcome, L. E. Akley, Dean of Engineering, University of South Dakota.

Employment for the Student Graduate, Professor W. C. DuVall, Counselor, University of Colorado Branch; Darrell Schneider, Chairman, University of Nebraska Branch.

In the papers by Professor DuVall and Mr. Schneider and in the discussion which followed, much emphasis was placed upon the need of students for more complete and more accurate information regarding the kinds of work that will be available to them immediatley after graduation. Some of the methods by which it was thought such information could be secured are inspection trips, summer employment, advice from faculty members who spend their summers in the industries, Branch programs devoted to summer experiences and other subjects connected with work in the various companies, and letters from former students to the faculty members. Professor DuVall emphasized the benefits received by the students from the District Conferences on Students Activities.

Saturday Morning Session

Vice-President O. J. Ferguson, presiding

Importance of the A. I. I. E. in Engineering Practise, Professor G. H. Sechrist, Counselor, University of Wyoming Branch; H. R. Arnold, Chairman, University of Colorado Branch; Henry Sattler, Chairman, South Dakota State School of Mines Branch.

The Branch as a Means of Teaching Ethics and the Highest Type of Professional Spirit, Professor F. W. Norris, Counselor, University of Nebraska Branch; Professor R. E. Nyswander, Counselor, University of Denver Branch; J. N. Petrie, Chairman, University of Denver Branch.

Methods of Stimulating Interest in the Branch, Professor D. R. Jenkins, Counselor, University of North Dakota Branch; Ervin Moudy, Chairman, University of Wyoming Branch; John K. Walsh, Chairman, University of North Dakota Branch.

Discussion of each of the above subjects was held immediately after the final presentation on that subject. Several speakers mentioned the various services of the Institute in contributing to the progress of electrical engineering and the development of its members. The many advantages offered to students through membership in the Branches were enumerated, and the importance of Branch activities in the future development of the Institute was emphasized. Some of the methods suggested for increasing interest in Branch meetings were talks by students on actual experiences, reading, or research; choice of most suitable time for meetings; appointment of more students on committees; and the serving of refreshments. The Conference received invitations to hold the next meeting at the University of Wyoming and the University of Denver. It was decided that the Executive Committee should choose the location.

Dr. B. B. Brackett, Counselor of the University of South Dakota Branch, was elected to represent the District Committee on Student Activities at the Annual Summer Convention at Swampscott.

Vice-President Ferguson urged that students in the District submit papers for the A. I. E. E. prizes.

Votes of thanks were extended to Dean L. E. Akley and University of South Dakota for the many considerations shown to the delegates, S. B. Hughes for his interesting address, and Vice-President Ferguson for his work of the past two years.

Luncheon, served to the delegates by the Home Economics Department of the University of South Dakota, was followed by an inspection trip to the new armory and gymnasium, the auditorium, and the museum.

STUDENT CONVENTION AT TROY, N. Y., MAY 10-11

A two-day Student Branch Convention will be held under the auspices of the North Eastern District of the Institute with headquarters at Rensselaer Polytechnic Institute, Troy, N. Y., on May 10 and 11.

A session devoted to Branch activities, a technical session with papers by Students, a banquet and inspection trips are the most important events of the meeting. The details of the program are given below.

Program

Friday, May 10

9:00 a. m.	Registration.
10:00 a. m.	Welcome by Director Ricketts of Rensselaer Polytechnic Institute.
10:15 a. m.	Session on Branch Activities. In this session a number of the various branch officers and members will outline the activities of their respective branches during the past year.
11:30 a. m.	District Executive Committee Meeting.
12:30 p. m.	Luncheon Conference at Hendrick Hudson Hotel for Counselors and incoming Chairmen of Branches.
2:30 p. m.	Technical Session. *A Short Discussion of Magneto-Striction Oscillators,* J. L. Daley and A. F. Metzger, Yale University. *Radiation Characteristics of Grounded Vertical "L" and "T" Antennas,* L. B. Hochgraf, Rensselaer Institute. *The Development of a New Type of Indicator for Electrical Measuring Instruments,* T. A. Rich, Harvard University.

Lighting in Industry, M. M. Hubbard, Massachusetts Institute of Technology.

Further Oscillographic Studies of Alternator Short Circuits, H. E. Furman and T. S. Bills, Cornell University.

The Story of a Lightning Surge, E. W. Jones, University of Maine.

6:30 p. m. Convention Banquet at Russell Sage, 2nd, Dining Hall.

Speakers: Dr. W. L. Robb, Head of the Department of Electrical Engineering at Rensselaer Polytechnic Institute.

Mr. E. B. Merriam, Vice-President of District No. 1, A. I. E. E.

Dr. W. R. Whitney, Director of the Research Laboratory, General Electric Company.

During the day the laboratories of the Rensselaer Polytechnic Institute will be open to inspection by visitors.

SATURDAY, MAY 11

A. m. Inspection trip through the Schenectady Works of the General Electric Company.

P. m. Inspection of Erie Barge Canal Lock.

Inspection trip through steam power plant of New York Power & Light Corporation at Cranesville.

PAST BRANCH MEETINGS

Alabama Polytechnic Institute

How Talking Pictures Have Changed the Movies, by T. S. Winter, student;

Rochelle Salt Crystals, by W. Kiester, student;

Carrier Current System of Alabama Power Company, by W. J. Marsh, student, and

Paper Mills, by L. E. Owens, student. March 21. Attendance 27.

Modern Business, by J. K. Smith, student, and

Photoelectric Effects, by G. A. Beavers, student. March 28. Attendance 27.

The Conduit Shop at Wilson Dam, by O. T. Allen, student;

The Dynamic Loud Speakers, by A. C. Cohen, student, and

The Electric Propulsion of Ships, by W. Nabers, student. April 4. Attendance 20.

University of Arizona

Talking Motion Pictures, by R. B. Bonney, Educational Director, Mountain States Tel. & Tel. Co. Illustrated with talking motion picture films. February 25. Attendance 220.

Charles P. Steinmetz, by Bernard Shehane, student, and

Lightning Protection of Oil Tanks, by Harold Soliday, student. March 13. Attendance 19.

The Beginnings of Electrical Science, by George Walton, student;

The Thury System of Power Transmission, by C. A. Macris, student, and

Nikola Tesla and His Achievements, by W. E. Tremaine, student. March 20. Attendance 18.

Motion Picture Projectors, by Kenneth Kelton, student. Illustrated with motion pictures. March 27. Attendance 18.

Odd Uses of Vacuum Tubes, by Leo Killian, student, and

Engineering and Economics, by John McBride, student. April 3. Attendance 19.

Bucknell University

Films on electrical measuring instruments. March 13. Attendance 11.

Business Meeting. The following officers elected for 1929-30: President, E. C. Metcalf; Secretary-Treasurer, R. G. Tingle. March 15. Attendance 12.

University of California

Business session. Three-reel film "The Single Ridge." March 13. Attendance 22.

The High Sierras, by Prof. J. N. LeConte. Slides.

Acoustics, by B. J. Gillham. April 3. Attendance 20.

Carnegie Institute of Technology

The Deion Circuit Breaker, by W. J. Ruano, student. Film "The Single Ridge." Election of officers. Social meeting and refreshments after program. March 6. Attendance 31.

University of Cincinnati

Chalk Talk, by Prof. Daniel Cook, Dept. of Applied Arts. November 22. Attendance 68.

Trends in Public Utility Development, by H. C. Blackwell, President, Union Gas and Electric Co. February 13. Attendance 50.

A. C. Network System and Protection, by L. L. Bosch, Asst. Engr., Columbia Engineering and Management Corp. March 7. Attendance 70.

Clarkson College of Technology

In the Lands of Buddha, by Prof. H. B. Smith, Worcester Polytechnic Institute. Illustrated. Afternoon meeting.

The Quest of the Unknown, by Prof. H. B. Smith. Illustrated. Banquet in honor of Prof. Smith. March 9. Attendance 410.

Talk by Laurence J. Gorman, Chief Test and Electrolysis Engineer, New York Edison Co., on that company and public utility problems. March 22. Attendance 80.

Clemson College

Michael Faraday, by Cadet F. Kellers;

Highest Head Water Power Development, by Cadet L. F. Sander;

Inertaire Transformers, by Cadet W. G. Parrott, and

Current Events, by Cadet C. R. Martin. Picture "The Welding of Pipe Line." March 7. Attendance 22.

Railroad Radio-Telephone Equipment, by Cadet R. L. Sweeny;

Why We Cannot Neglect Arc-Welding Equipment, by Cadet C. S. Lewis;

What Goes on Inside the D. C. Electro-Magnet, by Cadet F. W. Lachicotte, and

Current Events, by Cadet L. E. Marshall. March 28. Attendance 19.

Colorado Agricultural College

Synchronous Reproduction of Sound and Scene, by Prof. H. G. Jordan, Counselor. Paul H. Lindon elected Secretary to take office immediately. January 29. Attendance 16.

American Telephone and Telegraph Company, by G. W. Ball, senior. February 11. Attendance 15.

Work in the Graduate Students Course at the Westinghouse Plant in East Pittsburgh, Pa., by Bice Johnson (Alumnus), Westinghouse Electric & Mfg. Co. February 25. Attendance 20.

Movietone and Vitaphone, by R. B. Bonney, Educational Director, Mountain States Tel. & Tel. Co. Three reels motion pictures. March 11. Attendance 70.

Three-reel motion picture "Development and Construction of Transformers" shown by Prof. H. G. Jordan, Counselor. March 25. Attendance 16.

University of Colorado

Carrier Telephony, by R. B. Bonney, Educational Director, Mountain States Tel. & Tel. Co. Sound Pictures on the same subject. March 6. Attendance 190.

Opportunities with the General Electric Company, by M. M. Boring, General Electric Co. Brief talks and demonstrations by other representatives of the Denver office of the company. March 27. Attendance 80.

Cooper Union

Liberal Education for the Young Engineer, by President H. N. Davis, Stevens Institute of Technology. Joint meeting with three other engineering societies and two mathematical clubs. Reports of the year's activities in each were read by the respective secretaries. Music and two-reel comedy. Refreshments served after meeting. April 6. Attendance 100.

University of Denver

R. B. Bonney, Educational Director, Mountain States Tel. & Tel. Co., presented educational sound pictures demonstrating carrier telephony. He also demonstrated a portable talking moving picture outfit and described some new developments in the Bell Telephone Laboratories. March 15. Attendance 193.

Chairman J. N. Petrie gave an account of the District Conference on Student Activities held at the University of South Dakota on March 8 and 9 and gave a paper on *Some Photo-electric and Glow Discharge Devices and Applications to Industry*. (From February issue, A. I. E. E. JOURNAL). March 22. Attendance 13.

University of Kansas

Roy F. Dent, student, gave a talk on his work at the Hawthorne Plant of the Western Electric Company last summer. Business session. March 7. Attendance 54.

Twenty-first Annual Banquet. Murel Douglas, toastmaster. Talks were given by Chancellor E. H. Lindley, George Hulteen, freshman class, and Kenneth McMurray, junior class. "Beggars of Life," by Volney Holmes, senior class. Faculty responses by Prof. F. E. Johnson and Dean G. C. Shaad. J. L. Harrington, Consulting Engr., gave a talk on the necessity of continuing study after graduation. March 20. Attendance 185.

X-Ray Tube and Its Use in Industry, by Clarence Laughlin, Victor X-Ray Corp. Slides. March 26. Attendance 18.

Lafayette College

Business meeting. Earl C. Albert elected Chairman for next year. March 16. Attendance 20.

Lehigh University

The Stroboscope and Its Application to Alternator Stability, by C. W. Guyatt, '29, and

The Telephone Problems, by O. W. Eshbach, special assistant personnel officer, A. T. & T. Co. Slides. Election of officers. March 14. Attendance 76.

Lewis Institute

Application of Electricity in Medicine, Ultra Violet and Infra Red Machines, by Mr. Bladwin, Victor X-Ray Corp. March 19. Attendance 102.

Motion picture, "The Grinding Stone." April 9. Attendance 75.

University of Louisville

Business Meeting. Election of officers. April 4. Attendance 13.

Michigan State College

Informal meeting, sponsored by Faculty. Film on manufacture and construction of electrical devices. Refreshments served. February 24. Attendance 35.

Mississippi A. & M. College

The Advancement of Engineering in 1928, by John Liston, General Electric Co. March 6. Attendance 50.

University of Missouri

Imhotep, the First Engineer, by Prof. J. E. Wrench, History Dept. Joint meeting with Engineers Club. March 18. Attendance 202.

A Method of Investigating Surface Iron Losses, by R. A. Foltz and H. E. Gove. Adoption of Constitution and By-Laws. March 25. Attendance 21.

Montana State College

F. W. Jordan, Westinghouse Electric & Mfg. Co., Butte, Montana, gave a synopsis of Westinghouse activities and the opportunities offered to college graduates. March 14. Attendance 92.

R. B. Bonney, Educational Director, Mountain States Tel. & Tel. Co., gave a demonstration of a talking-moving picture machine. April 1.

The Magneto Aircraft Compass, by T. R. Rhea, from *General Electric Review* April 1929. Presented by Eitaro Etow, student.

Strange Eyes That Never Sleep, by A. A. Stuart, from *Popular Science*. Presented by Frank Brown, student, and

Airway Guides and Markers, by O. W. Bard, from *Electrical World*, March 1929. Presented by Murray Davidson, Student. April 4. Attendance 73.

University of Nebraska

Prof. F. W. Norris, Counselor, gave a report on the Conference on Student Activities held at University of South Dakota, March 8 and 9. M. E. Scoville and E. R. Saylor, students, spoke on their experiences in summer employment. Business session. March 15. Attendance 51.

Necessity of a Broad Education for the Engineer, by C. N. Chubb, President, Iowa and Nebraska Light and Power Co. Film, "Airport Lighting." March 28. Attendance 35.

Newark College of Engineering

History of Ice Cream and How It is Made Today, by Mrs. Carolyn V. Wright, Dietitian, Castle Ice Cream Co. Reel of motion pictures. Refreshments served after the meeting. March 18. Attendance 31.

Electric Welding in Steel Fabrication, by Prof. A. A. Nims. Illustrated. Business session. April 1. Attendance 22.

University of New Hampshire

Railroad Radio Telephone Equipment, by J. J. Donnelly, student;

Electric Equipment in North Station, Boston, by W. C. Adams, student, and

Some Developments During 1928, by J. F. Arren, student. March 9. Attendance 29.

College of the City of New York

Theater Party. March 22. Attendance 20.

Inspection trip to Otis Elevator Company, Yonkers, N. Y. March 28. Attendance 42.

University of North Dakota

Talk by J. D. Taylor, Branch Mgr., Northwestern Bell Telephone Co., Fargo, N. D., and illustrated lecture by Mr. Brown of same company, Omaha, Nebraska. March 14. Attendance 33.

Topics Discussed at the District Conference on Student Activities, by Prof. D. R. Jenkins, and

His Trip to the District Conference on Student Activities, by John Walsh, Chairman. April 9. Attendance 32.

Northeastern University

The Transmission of Power at High Voltages, by Prof. C. L. Dawes, Harvard University. Illustrated with slides. March 19. Attendance 132.

University of Notre Dame

Three-reel film "The Single Ridge." February 18. Attendance 175.

Railway Signals, by P. E. Rist, student, and

The Close Relationship Which Exists between Metallurgy and Electrical Engineering, by Dr. E. G. Mahin. Slides. After the talk guests were shown the metallurgical laboratory and the operation of the various appliances was explained. Refreshments were served. March 4. Attendance 60.

Magneto-Striction and the Methods of Its Measurement, by K. R. Weigand, student;

The Application of Electrical Grounds, by J. A. Northcott, Professor of Elec. Engg., and

Biographical Sketch of George Simon Ohm, by P. F. Murray, student. Refreshments served. March 19. Attendance 50.

Selling Street Illumination, by M. S. Gilbert, Illuminating Engr., Westinghouse Electric & Mfg. Co., South Bend, and

Manual to Automatic Telephone System Conversion, by R. A. Fenimore, Indiana Bell Tel. Co. Refreshments served. April 8. Attendance 55.

Ohio Northern University

Business Meeting. Election of officers. March 5. Attendance 18.

Quantum Theory, by Prof. Harrod, Head of Chemistry Dept. Social, Financial and Program Committees appointed. April 4. Attendance 12.

Ohio State University

The Romance of Power, by C. M. Ripley, Publicity Dept., General Electric Co. Slides. Chairman W. M. Webster gave an account of the Regional Meeting held in Cincinnati. Dinner meeting. April 3. Attendance 53.

Oklahoma A. & M. College

The 100-Kw. Tube, by H. E. Bradford, Secretary,

Railway Electrification, by E. L. Weathers, Chairman, and

Rival Theories of Life, by John H. Cloud, Professor of Physics and Head of Dept. Experiments. Illustrated lectures. Refreshments served. March 13. Attendance 51.

Economy of Electric Pipe Line Pumping, by W. G. Stueue, Commercial Engr., Oklahoma Gas & Elec. Co. March 27. Attendance 33.

Pennsylvania State College

Talks on Experiences with the New York Edison Company, by Mr. Bricker and President Bair. February 27. Attendance 38.

Talk, demonstrations and several reels of motion pictures on Lamps, by C. J. Campbell, Westinghouse Lamp Co. March 7. Attendance 48.

University of Pittsburgh

What is Expected of the Engineering Student After Graduation?, by H. A. P. Langstaff, West Penn Power Co. March 1. Attendance 64.

Columbia, Panama and Ecuador, by S. Q. Hayes, General Engr., Westinghouse Electric & Mfg. Co. Motion picture—"Proved." Light refreshments. March 8. Attendance 36.

Princeton University

Some of the Problems of Television, by W. Wilson, student, and

Current Limiting Reactors, by W. F. Beasley, student. March 22. Attendance 10.

Rhode Island State College

Light. Lecture and experiments by Prof. C. L. Coggins, Head of Physics Dept. March 8. Attendance 15.

Inspection trip to Peacedale Mfg. Co., Peacedale, R. I. March 14. Attendance 15.

Copper Mining in Michigan, by Prof. Wm. Anderson, Counselor. March 22. Attendance 19.

The Pawtucket Hydrogen-Filled Synchronous Condenser, by F. E. Caulfield, student. Discussion of participation in student convention to be held in Troy. April 5. Attendance 14.

Rutgers University

High-Speed Circuit Breakers in Electric Railways, by W. Breazeale, '29, and

Ground Detection in Isolated D. C. and A. C. Circuits, by Mr. Wolf, '29. February 12. Attendance 25.

Deion Circuit Breakers, by Mr. Shervo, '29, and

Recent Improvements on Turbo-Generators, by Mr. Walton, '29. February 19. Attendance 27.

Quantitative Mechanical Analysis of Power System Transient Disturbances, by Mr. Welch, '29, and

Lightning Protection for the Oil Industry, by H. Lehman, '30. February 26. Attendance 26.

Milwaukee Locomotives, by H. Hobson, '29, and

The Conowingo Power Installation, by G. Weglener, '30. March 5. Attendance 27.

Motion pictures, entitled "Building New York's Newest Subway" and "Driving the Longest Railroad Tunnel in the Western Hemisphere." Joint meeting of all engineering students. March 12.

University of Santa Clara

Business Meeting. February 1. Attendance 13.

Motion picture, "Liquid Air." Business session. February 12. Attendance 18.

Motion picture, "The Single Ridge." Joint with Engineering Society of the University. February 22. Attendance 87.

Motion pictures, "Building New York's Newest Subway" and "Driving the Longest Railroad Tunnel in the Western Hemisphere." March 7. Attendance 74.

University of South Carolina

The Theory of Relativity, by T. F. Ball, Counselor. Discussion of A. I. E. E. regional and national prizes. Importance of papers from the Branch emphasized. March 6. Attendance 18.

Business Meeting. Following officers elected for next year: Chairman, G. H. Preacher; Vice-Chairman, F. H. Lucas, Jr., and Secretary-Treasurer, B. F. Karick. April 10. Attendance 14.

South Dakota State School of Mines

Chairman Henry Sattler reported upon District Conference on Student Activities held at University of South Dakota. Prof. J. O. Kammerman, Counselor, gave a talk on Student Enrolment. Prof. E. E. Clark spoke on his summer school experience at Pittsburgh, Pa. Motion pictures, "The Okonite Process of Wire Making" and "The Land of Cotton." Refreshments served. March 13. Attendance 46.

Talking Pictures, by M. E. Murphy, (alumnus), Electrical Research Products, Inc. March 26. Attendance 28.

University of South Dakota

Vacuum Tubes, by Howard Crosby, student. Business session. March 11. Attendance 10.

Discussion of plans for joint meeting in Omaha in April. March 18. Attendance 15.

University of Southern California

Oil and Vacuum Switches, by Mr. Blaksley, Bureau of Power and Light, City of Los Angeles. February 14. Attendance 23.

Business Meeting. February 21. Attendance 23.

Effect of Power Factor Variations on Primary and Secondary Voltages, and Output of Five K. W. Street Lighting Transformer, by D. R. Stanfield, student. February 28. Attendance 24.

Joint meeting with California Institute of Technology Branch and Los Angeles Section. More complete report may be found on page 331 of April JOURNAL. March 5. Attendance 240.

Business Meeting. March 7. Attendance 21.

Business Meeting. March 14. Attendance 21.

Syracuse University

Calculation of Forces on Automatic Circuit Breakers, by Mr. Allen, student, and

Electrification of a Steel Mill, by Chairman F. Casavant. W. R. McCann, Chairman, Syracuse Section, was a guest of the Branch and participated in a discussion concerning the relationship between the local Section and the Student Branch. Luncheon. February 14. Attendance 22.

Demand Limitator, by E. T. Moore, Consulting Engr. March 7. Attendance 21.

Armature Voltage Rise in a Given Time, by Mr. Bryant, student, and

Design of Plunger Type Relay and Design of a Flywheel, by Mr. Ott, student. March 14. Attendance 21.

Power Factor Correction, by Mr. Belayeff, student, and

Inductance Calculation, by Mr. Rosti, student. March 21. Attendance 21.

University of Texas

Underground Distribution Systems, by Mr. Evans, San Antonio Public Service Co. Business session. March 14. Attendance 16.

University of Vermont

Branch meeting postponed and about twenty members attended the meeting of the Vermont Society of Engineers. Papers of particular interest to Branch members were: *Electrical Science*, by C. D. Spencer; *Power Development*, by F. M. Eastman, and *The Development of Water Power as a Natural Resource*, by M. G. Clark. March 13. Attendance 20.

Demonstration of Induction Motor Principles, by K. H. MacGibbon, '29, and

Types of Induction Motors, by J. W. Wendt and A. Johnson, '29. Discussion of plans for sending a delegation to the Student Convention at Troy. March 27. Attendance 16.

Virginia Military Institute

Summer Work in a Motor Generator Plant, by M. R. Berry, student;

Holland Tubes, by A. F. Black, student;

Electrification of Rolling Mills, by W. B. Miller, student;

Airplane Testing, by B. T. Smith, student, and

Use of Radio Telephony in Railroading, by W. B. Andrews, student. March 4. Attendance 40.

Carrier Current on Power Lines, by J. C. Smith, student;

Benefits of the A. I. E. E., by H. B. Blackwood, student;

Experiences with the Gas Wells of Texas, by J. T. Brodnax, student;

New Type of Generator Ventilating Fan, by C. A. Goodwin, student, and

Philadelphia Arena and Its Electrical Equipment, by A. S. Britt, student. March 28. Attendance 39.

Virginia Polytechnic Institute

Advice to College Men, by Prof. L. J. Bray. March 7. Attendance 32.

Motion picture, "Construction and Operation of Electrical Measuring Instruments." March 25. Attendance 100.

Washington State College

Engineers' Show Committee appointed. Discussion of plans for exhibits. February 28. Attendance 13.

Discussion of plans for Engineers' Show. March 6. Attendance 19.

Mining and Electricity, by Guy E. Ingersoll, Asst. Prof. of Mining and Metallurgy. Discussion of plans for Engineers' Show and plans to get more members to attend meetings. March 13. Attendance 15.

Prof. R. D. Sloan, Counselor, spoke on the A. I. E. E. organization—purposes and publications—and urged juniors to enroll in the Institute. Harold Low, graduate student, gave a talk on the Cathode Ray Oscillograph. Business session. Refreshments. March 27. Attendance 56.

University of Washington

The Seattle Distribution System of the Puget Sound Power and Light Company, by Ray Rader, Puget Sound Power and Light Co. and Secretary of the Seattle Section. Business session. April 5. Attendance 20.

West Virginia University

Electric Heat for Homes, by Earl Milan, student; *Purified Textile Insulation*, by G. H. Hollis, student; *Projection of Sound and Scene*, by Ivan Vannoy, student; *Rate Making*, by M. C. Clark, student; *Early Development of the Electric Railway*, by T. R. Cooper, student, and *Aeroplane Show at Pittsburgh*, by C. L. Walsh, student. March 11. Attendance 22.

Treated Fabric for Insulation, by C. A. Bowers, student; *Photo-electric Cells*, by C. B. Seibert, student; *Steel Used in Switch-board Design*, by J. R. Nothingham, student; *Defects of Insulation*, by O. R. Allen, student; and *Hydrogen for Cooling Electric Machines*, by S. N. Giddings, student. March 18. Attendance 21.

Telemetering, by J. Kayuha, student; *How Hard is Rock*, by W. H. Ross, student; *The Deion Circuit Breaker*, by L. F. Oneacre, student; *Structural Steel for Generators*, by R. H. Pell, student; *Electric Aid for Navigation*, by W. C. Warman, student; and *Designing Arc Welded Machine Bases*, by G. S. Watson, student. March 25. Attendance 22.

The Use of Chromium in Alloys, by V. O. Whitman, student; *Precision in Frequency Measurements*, by L. F. Oneacre, student; and *Power Interruptions by Birds*, by E. M. Hansford, student. April 8. Attendance 15.

University of Wisconsin

Chairman Odbert outlined the meetings for the second semester February 19. Attendance 21.

Banquet. Several seniors read reports on Eastern and Western inspection trips. Discussion of the trips by students and faculty. February 28. Attendance 50.

General discussion by faculty and students on the Electrical Engineering Course at the University of Wisconsin, lead by Prof. Edward Bennett, Department Head. March 27. Attendance 18.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these Founder Societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES, MARCH 1-31, 1929

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

DIE ANISOTROPEN FLUSSIGKEITEN.

By C. W. Oseen. Berlin, Gebrüder Borntraeger, 1929. (Fortschritte der Chemie, Physik und Physikalischen Chemie, ser. B., bd. 20, heft 2). 87 pp., 10 x 6 in., paper. 6.80 r. m.

In this concise treatment of anisotropic, or crystalline, liquids, the author does not attempt to review again our knowledge of the entire field. His interest is restricted to those facts about these substances for which a theoretical explanation has been proposed. The various phases which these liquids assume are discussed and the theories of different investigators given.

BEGRENZUNG DER LEISTUNGSSTEIGERUNG DER SCHNELLAUFENDEN VERBRENNUNGSMACHINE DURCH DEN STEUERVORGANG.

By Manfred Christian. (Forschungsarbeiten, heft 315). Berlin, V. D. I. Verlag, 1929. 19 pp., diagrs., tables, 12 x 9 in., paper. 3,75 r. m.

An investigation of the attainable limit of speed for high-speed internal combustion engines, such as those used for automobiles and airplanes, and especially of the extent to which this limit is fixed by the capabilities of the valve gear. The author investigates the various valve-gears which have been applied to four-cycle engines and determines the highest speeds possible for various sizes. Sleeve valves and rotary valves, he concludes, offer no hope for speeds higher than those obtainable with ordinary valves.

CAUSERIES SUR LES FILONS METALLIQUES.

By Paul Audibert. Paris, Dunod, 1929. 240 pp., 10 x 7 in., paper. 33 fr.

Every young engineer finds himself faced by numerous practical problems, the solution of which is not given in the theoretical treatises which he has studied. The author of this book, a young mine manager, has had the thought of writing the results of his experience with various difficulties, for the benefit of other young mining engineers.

This book is a supplement to the ordinary texts on mining. He discusses from a practical point of view, the characteristics of veins of ore, methods of draining and working, machinery, crushing, flotation, etc. The management of labor, mine organization, welfare work and similar topics are touched upon. The young engineer upon his own, especially abroad, should find the book suggestive and helpful.

LES COMPTEURS D'ELECTRICITE.

By R.-M. Fichter. 2d edition. Paris, Dunod, 1929. 372 pp., illus., diagrs., 10 x 7 in., paper. 73,90 fr.

A revised and rewritten edition of a work first published in 1919. The treatment is descriptive. Chapters are devoted to the various types of meters; to questions of installation, calibration, and testing; to methods of charging for current, to the organization of meter service, and to frauds.

CONDUCTION OF ELECTRICITY THROUGH GASES, v. 1. 3rd edition.

By Sir J. J. Thomson & G. P. Thomson. Cambridge, Eng., University press, 1928. N. Y., Macmillan Co., 491 pp., illus., diagrs., tables, 9 x 6 in., cloth. $8.50

The first edition of this celebrated work appeared in 1904; in 1906 a second edition appeared; and part of a third edition was in type when the War broke out and interrupted work upon it. It is only now that the author has been able, with the assistance of his son, to complete the task of dealing with the researches on this subject that have been made since the second edition.

The book has grown to two volumes, of which the first, dealing with the general properties of ions and ionization by heat and light, is now published. Most of the original paragraphs have been retained with little alteration except the replacement of the values of fundamental consultants by more accurate modern ones. The new matter is inserted at appropriate places. This book will be welcomed by workers in this field.

DAMPFTURBINEN.

By Leonhard Roth. Berlin, R. Oldenbourg, 1929. 103 pp., diagrs., tables, 10 x 7 in., paper. 6,-r. m.

Dr. Roth gives a concise presentation of the principles of the design and construction of steam turbines, from which advanced mathematics is absent. Starting with a description of the principles of the turbine, he develops the design of the various parts, then the combination of these into a complete machine. Modern tendencies in design and modern constructions are discussed.

DICTIONARY OF AMERICAN BIOGRAPHY. Under the Auspices of the American Council of Learned Societies.

Edited by Allen Johnson. N. Y., Charles Scribner's Sons, 1928. 20 v., 7 x 10 in., cloth. $250.00 per set.

Early in the present century there developed among the learned societies of America a serious discussion of ways and means of bringing into being a dictionary of American biography which would be, for students of America, what the Dictionary of National Biography is to his colleague in Great Britain. An organization was effected, Mr. Adolph S. Ochs provided a half-million dollars for editorial work and actual preparation of copy was begun in 1925.

The managers of the work plan to include biographies of all former inhabitants of America who have made "some outstanding contribution to the tradition of America." Unusual effort has been made to make the list of names complete and to include in it certain classes who are too often neglected in works of this character.

The first volume, a handsomely printed book of 660 pages, begins with Cleveland Abbe, astronomer and meteorologist, and ends with Maurice Barrymore, actor. The first engineer to appear is Brig.-Gen. Henry L. Abbot, well known for his important early work on hydraulics and the regimen of the Mississippi River; the last is Joseph Barrell, the geologist and teacher at Lehigh and Yale.

Between these extremes the lives are recorded of forty-four other engineers and manufacturers. Among them are such men as John F. Appleby, who invented the knotter used on most grain reapers; the metallurgists, Albert Arents and Philip Argall; Isaac Babbitt, of babbitt-metal fame; the Loammi Baldwins, father and son; Mattheas W. Baldwin; Albert Ball; and Zenus Barnum, prominent in the organization of early telegraph lines, but best known as the proprietor of the famous Barnum's Hotel in Baltimore.

Others of note are Horace Abbott, who rolled the armor-plate for the *Monitor*; Alexander Agassiz; James P. Allaire, theengine builder; Horatio Allen and John F. Allen; John R. Anderson, whose Tredegar Iron Works was the backbone of the munitions supply of the Confederacy; Oakes Ames and Oliver Ames; and David Alter, the pioneer physicist.

Each biography is written by a competent authority, and the sources for the statements are given. The standard is high and as it undoubtedly will be maintained through the remaining volumes, the dictionary will be in the first rank if indispensable works of reference.

It is planned to be completed in twenty volumes, containing 16,000 biographies.

DIESELLOKOMOTIVEN.

By G. Lomonossoff. Berlin, V. D. I.-Verlag, 1929. 304 pp., illus., diagrs., plates, tables, 12 x 9 in., cloth. 32.-r. m.

Professor Lomonossoff gives a very able study of the present position of the Diesel locomotive in this volume. The evolution of the machine, its theory and construction are discussed in the light of the researches of the author and his colleagues, and current practice is subjected to keen critical investigation. The various types of transmission are discussed at length.

ECONOMICS OF WATER POWER DEVELOPMENT.

By Walter H. Voskuil. Chic. & N. Y., A. W. Shaw Co., 1928. 225 pp., diagrs., maps, tables, 8 x 5 in., cloth. $3.00.

The author has attempted to analyze the factors that govern the economic exploitation of waterpower resources. He first lays down the principles of waterpower economy, calling attention to the elements of cost. The water powers of various sections of the United States are then discussed, after which the public control of water powers and the various projects for public ownership are taken up. Much statistical material is summarized and a good bibliography is given.

ELECTRICAL ENGINEERING ECONOMICS.

By D. J. Bolton. Lond., Chapman & Hall, 1928. 305 pp., diagrs., tables, 9 x 6 in., cloth. 21s.

Most books on economics for engineers, says this author, dwell almost exclusively on the economics of production and neglect the economics of consumption, the processes in which the greatest waste occurs.

The present book, devoted to the latter portion of the problem, aims to give electrical engineers and students a plain account of such elementary economics as most nearly concerns them, with its application to certain engineering problems. The first section presents general principles of economics. In the second, the choice of plant, the general problem of economic choice is treated. The final section deals with some of the economic problems connected with electricity supply, tariffs, load factor, power factor, etc.

ELEKTROTECHNIK, bd. 3; Die Wechselstromtechnik.

By J. Herrmann. 5th edition. Ber. u. Lpz., Walter de Gruyter & Co., 1929. 140 pp., plates, diagrs., 6 x 4 in., cloth. 1,50 r. m.

This volume of Professor Herrmann's little textbook on electrical engineering is devoted to a-c. machinery. Generators, transformers and motors are described clearly and very concisely, the principal theoretical points being explained and attention given also to practical questions of construction and operation.

HANDBOOK OF CHEMISTRY AND PHYSICS. Comp. by Charles D. Hodgman and Norbert T. Lange. 13th edition. Cleveland O., Chemical Rubber Co., 1928. 1214 pp., tables, 7 x 5 in., fabrikoid. $5.00.

The thirteenth editon contains over a hundred more pages than the preceding one, including a section on ceramics. Many changes have been made in the tables, to make them more convenient, and corrections have been made where required.

The book is a very valuable tool for the chemist and physicist, providing in convenient form a great mass of the data that are frequently wanted in the laboratory and chemical works.

HANDBOOK OF HYDRAULICS.

By Horace Williams King. 2d edition. N. Y., McGraw-Hill Book Co., 1929. 523 pp, diagrs., tables, 7 x 4 in., fabrikoid. $4.00.

This book is intended primarily to assist in the solution of hydraulic problems, and presupposes a knowledge of the principles of hydraulics. The author discusses the formulas used and presents a great amount of tabulated data that will simplify calculation.

The new edition extends the application of the Manning formula to flow in pipes. A new chapter on critical depth and hydraulic jump has been added, as well as additional data on natural streams and the measurement of flowing water. The entire text has been rewritten.

HEIZUNG UND LUFTUNG.

By Johannes Körting. Berlin, Walter de Gruyter & Co., 1929. 2 v., illus., tables, 6 x 4 in., cloth. 1,50 r. m. each.

A brief review of the design and construction of heating and ventilating installations in dwellings. The subject is presented in simple language, in a manner suited to the needs of builders and owners.

ILLUSTRATED TECHNICAL DICTIONARIES in . . . English, German, Russian, French, Italian, Spanish; v. 11, Electrical Engineering and Electrochemistry. Edited by Alfred Schlomann. Berlin, Technische Wörterbücher-Verlag, 1928. Distributors, V. D. I.-Verlag. 1304 pp., illus., 10 x 7 in., cloth. 80,-mk.

Every translator of electrical literature owes a vote of thanks to the editor of this work, and to the Society of German Engineers, which provided the funds for it. In its present form it is practically a new work, as it has been revised and reset, and greatly enlarged over the previous edition.

Approximately 20,000 expressions common in electrical literature are given, with their meanings in the six principal European languages. In preparing the work, the editor has had the assistance of expert engineers in each country. Wherever possible, the meaning of an expression is clarified by a sketch, formula or symbol.

The dictionary is indispensable to every translator or reader of foreign literature. It is by far the best available aid.

DER INDIZIERTE WIRKUNGSGRAD DER KOMPRESSORLOSEN DIESELMASCHINE.

By Fritz Schmidt. (Forschungsarbeiten, heft 314), Berlin, V. D. I.-Verlag, 1929. 22 pp., diagrs., tables, 12 x 9 in., paper. 4,50 r. m.

The investigation here reported was undertaken to make it possible to determine the indicated efficiency of Diesel engines more exactly and simply than has been the case in the past. The author subjects the customary methods to a critical study, and finally develops a method by which the indicated efficiency may be simply determined with the aid of certain tables and diagrams which he supplies.

KOMPRESSORLOSE DIESELMOTOREN UND SEMIDIESELMOTOREN.

By M. Seiliger. Berlin, Julius Springer, 1929. 296 pp., illus., diagrs., 10 x 7 in., bound. 37.50 r. m.

This treatise discusses these types of engines theoretically and practically. The author presents a new theory of the in-

ternal combustion engine, in which the working process is regarded as a function of the process of combustion, time, and cooling. The laws of the combustion process are investigated and applied to semi-diesel and compressorless diesel engines. The principal commercial types of engines are examined and practical conclusions drawn.

LIFE OF GEORGE CHAFFEY; A Story of Irrigation beginnings in California & Australia. By J. A. Alexander. Melbourne, Macmillan & Co., 1928. 382 pp., illus., ports., maps, 9 x 6 in., cloth. $10.50. (Gift of Macmillan Company, N. Y.)

George Chaffey arrived in California when irrigation development was in its primitive stages, and rapidly became an important pioneer in its advancement. He founded the Ontario colony, still a model of success, and devised the system of mutual water companies which has played a valuable part in promoting irrigation enterprises. Invited to Australia by the Victoria government, he founded the first larger-scale developments in that continent. Returning to the United States, he built the Imperial Valley works and the Whittier development.

His life is told in interesting fashion in this biography. Particular attention is given to the Australian period of his career, and the reasons for the financial failure of developments there is told in detail.

DIE MASCHINENELEMENTE, v. 2.

By Felix Rötscher. Berlin, Julius Springer, 1929. 1354 pp., illus., diagrs., tables, 11 x 8 in., bound. 48.-r. m.

The final volume of an important treatise on machine design, publication of which began in 1927.

The book has been given great praise in Germany, both for its comprehensiveness and for its method. Its especial virtue is the attention paid to questions of manufacture and working conditions. While the mathematical and kinematical factors are fully considered, the author also gives full attention to such matters as the most economical methods of forming the elements of a machine, the selection of the best material, the conditions under which the machine will be used, and other factors that affect the efficiency of the finished product. The result is an unusually practical reference book for designers and manufacturers.

MASTE UND TURME IN STAHL.

By P. Sturzenegger. Berlin, Wilhelm Ernst & Sohn, 1929. 219 pp., illus., diagrs., 10 x 7 in., paper. 23.-r. m.

This book, one of a library on steel construction planned by its publishers, is devoted to the construction of masts and towers for electric transmission and distribution systems. The author treats of the development and principles of line construction, transmission lines, trolley lines, anchorages and foundations, protection from corrosion, mast transportation and erection. Practical directions for design are given, and many types are illustrated and described.

NOMENCLATURE OF PETROLOGY.

By Arthur Holmes. Lond., Thomas Murby & Co., 1928. 284 pp., 7 x 5 in., cloth. 7/6.

A reliable dictionary of rock names, including the majority of those found in geological literature. The definitions are accurate, the introducer of each term is given, and there are numerous references to the literature. Glossaries of French and German terms and of Greek and Latin words and prefixes, are given in appendices.

The new edition is a reissue of the first, with corrections, at a greatly reduced price.

OPERATIONAL CIRCUIT ANALYSIS.

By Vannevar Bush. N. Y., John Wiley & Sons, 1929. 392 pp., 8 x 5 in., cloth. $4.00.

The purpose of this text is the presentation of the Heaviside operational calculus and allied matters in form for engineering use. It aims to bring together the substance of the developments and extensions of the methods introduced by Heaviside in his classic work, and to show how they may be applied to all sorts of circuit problems, not only in electricity, but also in acoustics, mechanics, hydraulics, and so on. The book is written primarily for engineers, rather than for mathematicians, and is based on experience in teaching the subject at the Massachusetts Institute of Technology.

PHYSICS OF THE AIR.

By W. J. Humphreys. 2d edition. N. Y., McGraw-Hill Book Co., 1929. 654 pp., illus., diagrs., tables, 9 x 5 in., cloth. $6.00.

In this work Dr. Humphreys discusses the whole range of physical phenomena of the earth's atmosphere and gives scientific or rational explanations of them. The book thus brings together in orderly arrangement much material that has been widely scattered and difficult to find.

The new edition contains an additional part, on meteorological acoustics, as well as many new paragraphs and topics.

PROFESSION OF ENGINEERING; Essays. Edited by Dugald C. Jackson & W. Paul Jones. N. Y., John Wiley & Sons, 1929. 124 pp., 8 x 5 in., fabrikoid. $1.50.

This collection of essays by noted engineers is designed primarily for the young man choosing a vocation. Starting with discussions of the education of the engineer and of the factors that make for success in engineering various authors describe the main branches of the profession. The final essay by President Hoover, is on the engineers contribution to modern life.

The authors suggest the book as a text for freshman orientation courses and courses in engineering English, and as a guide to parents and others interested in the profession and the qualifications necessary for entering.

RADIO. Edited by Irwin Stewart. Supplement to vol. 142 of the Annals. Phila., American Academy of Political and Social Science, 1929. 107 pp., 10 x 7 in., paper. Price not given.

The aim of this pamphlet is to give a picture of the entire field of radio in non-technical language. The articles, by many prominent specialists, deal with the development of radio, its present status, Federal legislation and its administration, its uses, and the part that it plays in international affairs.

RADIO RECEIVING TUBES.

By James A. Moyer and John F. Wostrel. N. Y., McGraw-Hill Book Co., 1929. 297 pp., illus., diagrs., tables, 8 x 5 in., cloth. $2.50.

Explains the principles underlying their action, tells how they are constructed and describes their uses, both in radio communication and for other industrial purposes. One chapter is devoted to specification for tubes for various purposes. The treatment is as nontechnical as is consistent with accuracy.

LE REGULATEUR AUTOMATIQUE POUR MACHINES ELECTRIQUES.

By Ernest Juillard. Lausanne, Switzerland, Payot & Cie, 1928. 176 pp., illus., diagrs., 10 x 6 in., paper. 6 fr.

The author has undertaken to interpret, by mathematical analysis, the transitory phenomena that occur at the moment when an automatic regulator comes into action. After having established a general method applicable to any type of regulator, the author makes use of it for the more special study of the automatic regulation of the voltage of generators. The mathematical results show the important role played by the various characteristics of the generator and regulator. The calculations are confirmed by a series of tests.

SPEECH & HEARING.

By Harvey Fletcher. N. Y., D. Van Nostrand Co., 1929. 331 pp., illus., diagrs., tables, 9 x 6 in., cloth. 5.50.

This work on the physics of speech and hearing makes available the results obtained by the author and his associates during thirteen years of work at the Bell Telephone Laboratories. It treats of the mechanism and character of speech, of the physical properties of musical sounds and noise, of the mechanism of hearing and its capacities and of the perception of speech and music.

STRATIGRAPHICAL PALAEONTOLOGY.

By E. Neaverson. Lond. & N. Y., Macmillan & Co., 1928. 525 pp., illus., 9 x 6 in., cloth. 6.50.

While textbooks of stratigraphy always contain some broad generalizations on the faunal aspect of stratal conceptions, says this author, the student is often left with inadequate conceptions of the application of paleontological methods to stratigraphy. The present book is designed to help him to use fossils to the best advantage in his geological work.

Part one discusses general considerations, such as mode of occurrence, habitat, geographical distribution, and migration. Part two is an account of the faunas of geological systems as they occur in Great Britain. The book contains accurate illustrations of some five hundred different kinds of fossils, which should be of service to mining engineers and geologists.

DIE THEORIE DER GEWICHTSSTAUMANERN.

By K. Kammüller. Berlin, Julius Springer, 1929. 60 pp., diagrs., tables, 9 x 6 in., paper. 5.40 r. m.

This little book discusses some important problems of dam design, its purpose being to present some valuable results of theoretical investigation into the strength of gravity dams in a form that will be easily applicable in practice. The topics treated include uplift, the pressure conditions, the stresses, and the position of the expansion joints.

THEORY OF HEAT ENGINES.

By William Inchley. 3d edition. N. Y., Longmans, Green & Co., 1929. 504 pp., diagrs., 9 x 6 in., cloth. $5.00.

In order to have space for a complete exposition of both the thermo-dynamical and mechanical principles of the subject, all purely descriptive matter has been omitted from this book. It aims to give concisely a thorough course in the theory of heat

engines, adapted to the courses given university students of engineering. The new edition has been edited by Dr. Arthur Morley, who has made various amendments and corrections.

VIBRATION PROBLEMS IN ENGINEERING.

By S. Timoshenko. N. Y., D. Van Nostrand Co., 1928. 351 pp., 9 x 6 in., cloth. $4.50.

An exposition of the fundamentals of the theory of vibrations with special reference to the application of the theory to such practical problems as the balancing of machines, the vibrations in turbines and in railroad track and bridges, and the whirling of rotating shafts. The topics discussed include harmonic and non-harmonic vibrations in systems with one degree of freedom, in systems with several degrees of freedom, and in elastic bodies. A chapter on measuring instruments is included. Applications to various engineering problems of importance are developed.

WARME-UND KALTESCHUTZ IN WISSENSCHAFT UND PRAXIS. 186 pp., illus., tables, 9 x 6 in., bound. 16.-r. m.

DIE GRUNDLAGEN FUR DEN VERGLEICH VON WARMESCHUTZ-ANGEBOTEN. 63 pp., diagrs., tables, 8 x 6 in., bound. 7,60 r. m.

DIE TECHNISCH-RECHTLICHE BEDEUTUNG VON GARANTIEN AUF DEM GEBIETE DES WARME-UND KALTESCHUTZES. 62 pp., 8 x 6 in., bound. 6,50 r. m.

Köln-Rhein, Deutsche Prioform Werke Bohlander & Co., 1928. For sale by Julius Springer, Berlin.

These three volumes issued by the Deutsche Prioform Werke contain technical data and advice to purchasers of heat-insulating materials based on the experience of that firm of manufacturers.

Wärme-und Kälteschutz is a general work on the principles and practice of heat insulation. The conduction of heat, the calculation of insulation, the testing of insulating materials, various methods of insulating, and the raw materials used are discussed. The book summarizes the data needed in designing and selecting materials and methods.

Grundlagen für Vergleich der Wärmeschutzangeboten aims to assist the buyer in comparing tenders from various firms. Technisch-Rechtliche Bedeutung von Garantien is a discussion of the technical and legal points of manufacturer's guaranties.

WEGE UND ZIELE DES DEUTSCHEN MUSEUMS. By W. Von Dyck.

HEINRICH HERTZ. By J. Zenneck.

(Deutsches Museum. Abhandlungen und Berichte, heft 1 & 2.) Berlin, V. D. I. Verlag, 1929. heft 1, 30 pp.; heft 2, 36 pp., illus., ports., 8 x 6 in., paper. 1,-r. m. each.

These pamphlets are the first two numbers of a bi-monthly publication which will be issued under the auspices of the Deutsches Museum and the Society of German Engineers, and which will be devoted to brief popular accounts of important technical developments, biographies of scientists and engineers, museum collections, etc.

The first number contains an account of the beginnings of the Deutsches Museum, of its organization, developments and purposes. The second is devoted to an account of the life and work of Heinrich Hertz, in which Dr. Zenneck gives an able brief review of his discoveries and their influence on electrical engineering.

WIDERSTANDSMESSUNGEN AN UMSTROMTEN ZYLINDERN VON KREIS-UND BRUCKENPFEILERQUERSCHNITT.

By F. Eisner. Berlin, Julius Springer, 1929. (Mitteilungen der Preussischen Versuchsanstalt für Wasserbau und Schiffbau, Berlin. Heft 4) 98 pp., illus., diagrs., tables, 11 x 8 in., paper. 10.-r. m.

This is an experimental contribution to the question of the resistance to motion of solids in liquids. It is the first portion of a comprehensive, systematic investigation of the resistance of structures resembling bridge piers in open channels, and of the effect of various shapes upon their resistance. The present report is in three parts. Part one shows the distribution of pressure and the amount of resistance in the case of cylindrical bodies. Part two is a review of the present teachings of hydrodynamics concerning resistance and the formulas proposed for computing it. Part three gives the results of experiments with bodies similar in cross-section to bridge piers.

These investigations were made at the Prussian Experimental Institute for Hydraulic Engineering and Naval Architecture, and have been in progress since 1913.

ZUGFESTIGKEIT UND HARTE BEI METALLEN.

By Otto Schwarz. (Forschungsarbeiten, heft 313). V. D. I. Verlag, 1929. 34 pp., diagrs., tables, 11 x 8 in., paper. 6 r. m.

With the growing use of non-ferrous metals and the very general use of the ball test upon semi-finished and finished products, a clear understanding of the theoretical and practical connections between tensile strength and hardness becomes very important. These relations are very carefully studied in this report. The author first investigates the question theoretically and derives laws showing the relationship. He then describes his laboratory investigations in detail, gives the experimental results obtained with brass, nickel, aluminum, duraluminium and skleron, and supplies tables, based on these results, giving the factors for converting hardness into tensile strength. The relation of strength to hardness for copper and steel at higher temperatures and for cast metals is also shown.

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contributions from the societies and their individual members who are directly benefited.

Offices:—31 West 39th St., New York, N. Y.,—W. V. Brown, Manager.

1216 Engineering Bldg., 205 W. Wacker Drive, Chicago, Ill., A. K. Krauser, Manager.

57 Post St., San Francisco, Calif., N. D. Cook, Manager.

MEN AVAILABLE.—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to ***EMPLOYMENT SERVICE, 31 WEST 39th Street, New York City,*** *and should be received prior to the 15th day of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary: temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

POSITIONS OPEN

ENGINEER, who is familiar with the design of watthour meters and current and voltage transformers. Apply by letter stating qualifications fully and salary expected. Location, Canada. X-7740-C.

ELECTRICAL ENGINEER, graduate of 1926 or earlier. Design experience in the audio frequency end of radio sets preferred. Apply by letter, giving age, training, experience and salary expected. Opportunity for advancement in sales engineering capacity. Location, Middle west. X-7800-C.

ASSISTANT ENGINEER, of electrical distribution to make studies and plans for future expansion of distribution system, both underground and overhead 4000-volt and 12,000-volt, for a large city. Must have had similar experience with power and light company in a city of at least

500,000 population. Apply by letter giving full details in first letter, including references, samples of work, salary expected, age and recent photograph. Traveling expenses paid for conference. Location, Canada. X-7850.

MEN AVAILABLE

ELECTRICAL ENGINEER, 36, single, B. S. in E. E.; seven years of public utility experience in laboratory and field testing of power and industrial equipment, protective relays and meters. Considerable oscillographic experience. Desires position with engineering or industrial concern. No preference as to location. C-5713.

RESEARCH ENGINEER, 32, M. I. T. graduate, M. S. in E. E. Six years' experience with power companies on important test and investigation work; five years in the research department of prominent manufacturer on research and development work. B-1041.

GRADUATE ELECTRICAL ENGINEER, 25, married, desires position with development, public utility or industry. Six years of practical experience in construction and maintenance; three years coal mine superintendent. Seeks change from present position for one with greater opportunities. Location, immaterial. Working knowledge of Spanish and French. C-5746.

ELECTRICAL ENGINEER, 33, married, degree E. E., Dordrecht, Holland, desires position as construction engineer with prospects of foreign service now or later. Seven years' experience, installation, testing, automatic telephone inspector, central office, emergency repairing, drafting, supervisory control. Speaks English, Dutch, French, German. Available for any location. Now employed. C-5733.

ELECTRICAL SALES AND CONSTRUCTION ENGINEER, 31, desires connection with reliable company; graduate of two technical colleges with ten years' varied experience; seven and one-half years with largest electrical manufacturer, graduate student electrical engineers test course, experience in turbine engineering, switchboard; district office and resident agent sales; also, specialty merchandizing. C-5618.

DESIGNING ENGINEER, 37, single. Electrical engineering graduate desires position as designing engineer; thirteen years' experience in the electrical industry, seven of which were spent with public utilities, designing power plants and handling material, estimating, specifications and valuation. Now employed. Location, immaterial. C-983.

TECHNICAL GRADUATE, University of Kentucky. Five years' experience power plant and substation layout and construction; Westinghouse Test. At present, instructor of engineering in large midwestern university. Desires either summer or permanent connection. C-5734.

RECENT GRADUATE, with degree of B. S. in E. E., 27, single. Attended radio school in Pennsylvania and will graduate from Ohio University. Has worked for power company in Pennsylvania, doing drafting work in connection with extension lines. Desirous of electrical work with a company where there are possibilities of advancement. Location, immaterial. Available June 15, 1929. C-5728.

METER AND INSTRUMENT SPECIALIST, 28, single, high school and evening technical school education; five years' experience in the design, manufacture and test of meters and instruments. Available, one month. Location, immaterial. C-5771.

NEBRASKA GRADUATE, 26, single. Five years' telephone experience, including manufacturing and operating; some sales experience. Desires connection which offers sales opportunity with a future within the corporation. Location, immaterial. Available to travel on short notice. C-5770.

GRADUATE ELECTRICAL ENGINEER, of wide experience in design of large power stations, steam and hydroelectric, high-tension indoor and outdoor substations and industrial plants. Has had executive and construction experience. Capable of responsible work. Has had some manufacturing, business and sales experience. Now employed. Location preferred, East or Southeast. B-9222.

ELECTRICAL ENGINEER, 32, married, 1924 graduate. Five years' experience as distribution engineer with one of the largest utility companies in the middle west; desires a position of responsibility with a utility or manufacturing company in the West or Southwest. C-5714.

ELECTRICAL ENGINEER, 1927 graduate, B. of E. E., 24, single. Two years' practical experience in electrical and gas substation construction and the handling of men in this work. Desires connection with industrial, construction company, or public utility. C-5782.

ELECTRICAL ENGINEER, 26, single, graduate, B. S. in E. E.; two years' of mechanical and electrical testing of power plant equipment in large public utility. Desires connection with public utility or industrial concern in Middlewest. Best references. C-5776.

ELECTRICAL AND MECHANICAL ENGINEER, sixteen years' experience, married, 32; desires position as superintendent of construction or maintenance engineer; four years general and electrical superintendent in large electrochemical plant. Location in South America or Canada, available at once. C-3671.

INDUSTRIAL ELECTRICAL ENGINEER; experience in application, construction and maintenance of electrical equipment in metal working industries. Desires position as plant engineer or manufacturer's representative. B-8918.

ELECTRICAL ENGINEER, desires permanent connection in any branch of electrical work in Philadelphia District. Age 34, experienced in consulting, design, construction and test of power houses, industrial plants, substations and lighting installations. C-2570.

RESEARCH PHYSICIST, Ph. D. Nationally known for remarkable record of electrical and radio inventions. Past positions: University Professor (head of Physics Department), and Director of Theoretical Research at prominent industrial research laboratory. Present salary $12,000 per annum. C-2048.

ELECTRICAL ENGINEER, B. S., 27, recent graduate; thorough knowledge of Spanish; working knowledge of Portugese; desires connection with concern doing business in South America. Location, immaterial. C-5811.

ELECTRICAL ENGINEER, graduate, married, willing to travel. Has had two years' experience on General Electric Test, one year's sales and contract service experience, three years in the electrical contracting business and one year on valuation and appraisal work. Desires to enter sales, inspection or installation work. Available on short notice. B-9090.

ASSISTANT PROFESSOR, E. E., now in utility work and with a background of ten years' experience in classroom, supplemented by practical experience during summers, desires return to college work, in South or West. Connections have been with first class organizations. Available on one month's notice. C-1599.

MECHANICAL-ELECTRICAL ENGINEER, with twenty years' experience in the design, construction and operation of manufacturing plants and their equipment; specialty is the operation and maintenance of large manufacturing plants. Training was obtained in plants employing over 5000 men. C-5088.

POWER AND MAINTENANCE ENGINEER, technical graduate; 15 years' experience in power plant and industrial power investigation layout and operation; departmental distribution of power, steam and costs. Thorough acquaintance with steam and electrical equipment. Desires position with industrial organization. Executive and business ability. Location near Philadelphia or New York preferred. B-7492.

SALES ENGINEER, American, 39, six years as sales engineer covering United States and Canada. Nine years present position, business executive spending most of time in foreign lands. Married, steady, good health, enjoy work. Personality that wears. Thorough sales and business training. Handles French correctly. Seeks sales engineering or export connection with reliable company. Location, immaterial. Now on Pacific Coast. C-5817.

ELECTRICAL ENGINEER desires position doing research or development work. Thoroughly trained and competent meter engineer. Experienced in combustion and general laboratory and power plant testing. Has been successful along development lines; also extensive public utility experience. C-5258.

ELECTRICAL ENGINEERING GRADUATE, 31, married, desires position with manufacturing concern, public utility or contractor. Has had nine years' experience with public utility, in power factor correction, trouble investigation, supervising customers' equipment and isolated power plant tests. Located in eastern Pennsylvania at present but will consider position elsewhere. B-6546.

GRADUATE ELECTRICAL ENGINEER-EXECUTIVE, now employed, 33, married; ten years' experience, design, supervision of construction, generating sub and railway converter stations; invites correspondence from public utilities where there is an opportunity for advancement. B-6600.

ELECTRICAL-MECHANICAL ENGINEER, 31, with over six years' experience, as Testing Engineer, Electrical Designer of a-c. and d-c. substations and transmission line engineer; very familiar with design of a-c. calculating boards and oscillograph, klydonograph and cathode-ray oscillograph investigations; able to analyze statistical engineering data; desires engineering position with manufacturing or public utility company. C-200.

SALES ENGINEER, desires position in district office of manufacturer of electrical equipment or as estimator in office of consulting engineer. University graduate in E. E., 39, married. At present employed in electrical engineer's office of coal mining company. Middle Atlantic States preferred. C-5835.

ENGINEER, with broad experience, both electrical and mechanical, in manufacturing desires position as chief engineer of a concern manufacturing electrical household appliances. Available on reasonable notice. A-4660.

ELECTRICAL ENGINEER, 36, married, with degrees in Science and Electrical Engineering; thoroughly experienced in the design and manufacture of electric sets, power supplies, power transformers, paper condensers; six years' experience in above products. At present employed as chief engineer, paper condensers, desires change. C-3277.

ELECTRICAL ENGINEER with twenty years' experience in making surveys, designs and supervising the construction of underground distribution systems. Has been exceptionally successful on recent three-phase four-wire systems. Individual surveys and designs considered on a monthly salary basis. Highest references from leading engineers. B-4272.

MEMBERSHIP—Applications, Elections, Transfers, Etc.

APPLICATIONS FOR TRANSFER

The Board of Examiners, at its meeting of April 3, 1929, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grade of Fellow

HALLBORG, HENRY E., Communications Engineer, Radio Corp. of America, New York, N. Y.

MARSHALL, ALFRED C., Vice-President and General Manager, The Detroit Edison Co., Detroit, Michigan.

To Grade of Member

BALDWIN, HOWARD D., Manager, Westinghouse Elec. & Mfg. Co., Wilkes Barre, Pa.

BAUMER, HARRY W., Acting Asst. Elec. Engr., Dept. of Gas & Electricity, Chicago, Ill.

BENNETT, JOHN W., Distribution Engineer, Eastern New Jersey Power Co., Asbury Park, N. J.

BOLICK, CLARENCE P., Operating Supervisor, Duquesne Light Co., Pittsburgh, Pa.

BROWN, ROBERT C., Jr., Plant Electrician, Public Lighting Commission, Detroit, Mich.

CLARK, J. HUNTER, Executive Asst. to Chief Elec. Engr. and Gen. Mgr., Bureau of Power & Light, Los Angeles, Calif.

CURTIS, LEO H., Foreman, General Electric Co., Erie, Pa.

CURTIS, LOUIS B., Supervisor of Substations, Pennsylvania Railroad, Philadelphia, Pa.

DANIELS, HENRY, Cost Engineer, Central Hudson Gas & Elec. Corp., Poughkeepsie, N. Y.

DARLAND, ALVIN F., Supt. Elec. Construction and Design, Public Utilities Dept., Tacoma, Wash.

DIAMOND, HARRY, Radio Engineer, Bureau of Standards, Washington, D. C.

DUNBAR, JOHN ROBERT, Electrical Engineer, Canadian Westinghouse Co., Hamilton, Ont., Can.

FERGUSON, JOHN G., Telephone Engineer, Bell Telephone Labs., New York, N. Y.

FROST, GEORGE, Power Sales Engineer, Lawrence Gas & Elec. Co., Lawrence, Mass.

GARVIN, JOHN P., Central Station Layout Engineer, W. S. Bartstow & Co., Reading, Pa.

GRAHAM, VIRGIL M., Radio Engineer, Stromberg-Carlson Telephone Mfg. Co., Rochester, N. Y.

GRIFFITH, R. T., Asst. Engr. of Transmission, Bell Telephone Co. of Pa., Pittsburgh, Pa.

HOGE, CARL H., Construction Supt., Puget Sound Pr. & Lt. Co., Seattle, Wash.

KAYLER, KENNETH W., Operating Engineer, Duquesne Light Co., Pittsburgh, Pa.

KELLY, JAMES F., Electrical Plant Engr., Public Service Elec. & Gas Co., Newark, N. J.

KIRKPATRICK, CHARLES M., Asst. Northeastern Central Station Mgr., Westinghouse Elec. & Mfg. Co., New York, N. Y.

LARSON, LUDVIG C., Instructor of Elec. Engg., University of Wisconsin, Madison, Wis.

LUMLEY, CHARLES S., Electrical Engineer, Smith, Hinchman & Grylls, Detroit, Michigan.

LUTHER, GEORGE D., Manager—Seattle Branch—Electric Storage Battery Co., Seattle, Wash.

MacGREGOR, JOHN R., Chief Engr., Bell Tel. Co. of Pa., Pittsburgh, Pa.

MATHES, ROBERT C., Communication Engineer, Bell Telephone Labs., New York, N. Y.

MESS, CHARLES T., Asst. Engr., California Railroad Commission, San Francisco, Calif.

MOON, PARRY H., Instructor, Mass. Inst. of Tech., Cambridge, Mass.

PAQUE, E. J., General Works Engineer, The Pollak Steel Co., Cincinnati, Ohio.

RITTER, RALPH W., Engineer, Electric Storage Battery Co., Philadelphia, Pa.

ROST, HELGE, Chief Electrical Engineer, Empresa de Telefonos Ericsson, S. A., Mexico, D. F. Mex.

SHANKLIN, GEORGE B., Elec. Engr., General Elec. Co., Schenectady, N. Y.

SILENT, HAROLD C., Elec. Engr., Electrical Research Products, Inc., Los Angeles, Calif.

STANNARD, JAY L., Chief Engineer, Cushman Power Project, Tacoma, Wash.

TEACH, FRANK A., Asst. Elec. Engr., Gusta Hirsch Organization, Columbus, Ohio.

TOWNSEND, WISNER R., Engineer, Baker & Spencer, Inc., New York, N. Y.

WALTON, PERCY J., Elec. Engr., General Elec. Co., Philadelphia, Pa.

WILLIAMS, HAROLD W., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

WOODWORTH, LEON B., Sectional Engineer, Central Mining & Investment Corp., Johannesburg, Transvaal, So. Africa.

YANG, SIH-ZUNG, Sales Manager, Elbrook Inc., Shanghai, China.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before May 31, 1929.

Adrian, M. J., Westinghouse Elec. & Mfg. Co., New York, N. Y.

Bartol, L. W., Westchester Lighting Co., Mt. Vernon, N. Y.

Bates, R. P., General Electric Supply Corp., Houston, Tex.

Baumgartner, R. P., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Baxter, F. H., Shawinigan Water & Power Co., Shawinigan Falls, Que., Can.

Berg, E. E., (Member), Pacific Power & Light Co., The Dalles, Ore.

Berry, R. U., General Electric Co., Schenectady, N. Y.

Bickford, C. L., Electrical Contracting, New Hampton, N. H.

Buchholz, W. F., Midwest Refining Co., Midwest, Wyo.

Buck, F. G., Pennsylvania Water & Power Co., Baltimore, Md.

Budden, D. V., (Member), Benjamin Electric Mfg. Co., New York, N. Y.

Butler, L. W., Wisconsin Telephone Co., Milwaukee, Wis.

Cain, J. T., Lousiana Power & Light Co., Sterlington, La.

Calverley, W. R., Railway & Industrial Engineering Co., Pittsburgh, Pa.

Carpenter, E. R., Iowa Southern Utilities Co., Centerville, Iowa

Carroll, W. L., Westinghouse Electrical International Co., New York, N. Y.

Carter, G. B. L., (Member), Southwestern Bell Tel. Co., Oklahoma City, Okla.

Chen, D. S., Globe Electric Co., Milwaukee, Wis.

Clark, L. B., P. O. Box 97, Parker, Indiana

Coe, E. R. C., International Communication Labs., Inc., New York, N. Y.

Cooney, R. T., Jr., J. G. White Engineering Corp., Boling, Tex.

Cooper, L. S., Philadelphia Rural Transit Co., Philadelphia, Pa.

Criss, F. W., Mississippi Power & Light Co., Lexington, Miss.

Cunning, J. C., Bureau of Power & Light, Los Angeles, Calif.

Dillon, H. A., Jr., Dillon Electric Service Station, Gloversville, N. Y.

Dinwiddie, E. H., Southwestern Bell Telephone Co., Oklahoma City, Okla.

Doherty, H., Steam Yacht "Viking," New York, N. Y.

Earnheart, R. L., General Electric Co., Erie, Pa.

Edwards, J. H., Jr., Kansas City Power & Light Co., Kansas City, Mo.

Ely, H. D., Kansas City Power & Light Co., Kansas City, Mo.

Emme, M. T., Western Electric Co., Minneapolis, Minn.

Evans, A. E., (Member), Commonwealth Edison Co., Chicago, Ill.

Evans, S., (Member), Hughes Tool Co., Houston, Tex.

Foster, J. A., Standard Public Service Co., Columbus, Ohio

Fredericks, P. G., (Member), Jeffery DeWitt Insulator Co., New York, N. Y.

Frendenthal, J., Brunswick, Balke, New York, N. Y.

Fuller, R. A., General Electric Co., Philadelphia, Pa.

Gebhardt, P. B., Colin B. Kennedy Corp., South Bend, Ind.

Gordon, M. K., Jr., Brandes Products Corp., Newark, N. J.

Groeneveld-Meijer, N. E., (Member), Allgemeine Elektricitats Gesellschaft, Schenectady, N. Y.

Hays, H. M., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Heinrich, J., Kansas City Power & Light Co., Kansas City, Mo.

Hopkins, P. E., Public Service Co. of No. Illinois, Chicago, Ill.

Howard, F. M., Mountain States Power Co., Casper, Wyo.

Ingersoll, H., United Illuminating Co., New Haven, Conn.

Jagou, C. C., Westinghouse Electric International Co., New York, N. Y.

James, H. C., Henningson Engg. Co., Omaha, Nebr.

Jurss, G. W., Val. Blatz Brewing Co., Milwaukee, Wis.

Kane, E. K., General Electric Co., Pittsfield, Mass.

Kenneally, M. M., (Member), Ohio Brass Co., New York, N. Y.

Knauer, G. W., Northwestern Bell Telephone Co., Fargo, No. Dak.

Knowles, H. F., Edison Electric Illuminating Co. of Boston, Dorchester, Mass.

Knox, J. A., Bell Telephone Co. of Pa., Pittsburgh, Pa.

Lamperti, L., United Electric Light & Power Co., New York, N. Y.

Larsen, L. P., Ford Motor Co., St. Paul, Minn.

Levy, M. W., Kansas City Power & Light Co., Kansas City, Mo.

Lewis, M. T., Southwestern Bell Tel. Co., Dallas, Tex.

Lyons, S. H., Southwestern Bell Telephone Co., Oklahoma City, Okla.

Malone, J. F., Claude Neon Lights, Inc., Long Island City, N. Y.

Marrs, R. E., General Electric Co., Schenectady, N. Y.

Mathewson, P. L., Canadian Westinghouse Co., Hamilton, Ont., Can.

McDonald, R., 2 Ord St., San Francisco, Calif.

McKinnes, J., Watson-Flagg Engineering Co., Paterson, N. J.

Meurer, E. E., Bell Telephone Co. of Penna., Pittsburgh, Pa.
Moody, F. B., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Moorhouse, C. E., Canadian Westinghouse Co., Ltd., Hamilton, Ont., Can.
Morf, E. B., Latourrette Fical Co., San Francisco, Calif.
Morris, W. G., Home Tel. & Tel. Co., Spokane, Wash.
Mumm, A., Leeds & Northrup Co., Philadelphia, Pa.
Murr. A., Interborough Rapid Transit Co., New York, N. Y.
O'Connor, F. P., Interborough Rapid Transit Co., New York, N. Y.
Pace, G. L., Ingenio Santa Fe C. por A. San Pedro de Macoris, Dominican Republic
Palmer, O. H., Mississippi Power & Light Co., Lexington, Miss.
Parlas, J. L., 103 East Madison Ave., Niles, Ohio
Paxton, E. T., General Electric Supply Corp., Dallas, Tex.
Pettibone, G. W., American Tel. & Tel. Co., New York, N. Y.
Phillips, F. L., Kansas City Power & Light Co., Kansas City, Mo.
Pohl, A., (Member), Westinghouse Elec. & Mfg. Co., Newark, N. J.
Rathbun, H. V., Kansas City Power & Light Co., Kansas City, Mo.
Reis, J. F., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Richardson, G. B., Texas Power & Light Co., Dallas, Tex.
Rindlaub, W. W., Philadelphia Electric Co., Philadelphia, Pa.
Russell, C. E., Russell's Radio Service, Coffeyville, Kans.
Schuler, K. E., Central West Public Service Co., Omaha, Nebr.
Scribante, P. P., Star-Delta Electric Works, San Francisco, Calif.
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Warner, J. L., Chesapeake & Potomac Telephone Co., Baltimore, Md.
While, E. M., New York Edison Co., New York, N. Y.
Whitaker, D. W., West Texas Utilities Co., Abilene, Tex.
Williams, V. C., Jr., W. S. Barstow & Co., Inc., Reading, Pa.
Total 104.

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Fellows, H. S., Melbourne Electric Supply Co., Ltd., Melbourne, Australia
Kaul, R. K., Kashmir Hydro-Electric Installation, Baramulla, Kashmir, India
Mera, J. R., Porto Rico Irrigation Service, Villalba, Porto Rico
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Sampaio, L. F., Companhia Paulista de E. F., Jundiahy, Sao Paulo, Brazil, So. America
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Subramanian, P., Water Works Division, Coimbatore, Deccan, India
Tandon, C. P. L., Lahore Electric Supply Co., Lahore, Punjab, India
Upadhia, J. P., East Indian Railway, Cawnport Junction, U. P., India
Total 12.

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DIGEST OF CURRENT INDUSTRIAL NEWS

NEW CATALOGUES AND OTHER PUBLICATIONS

Mailed to interested readers by issuing companies

Transformers.—Bulletin 1724-A, 16 pp., Modern Power Transformers.—Describes the manufacture, testing and auxiliaries of Westinghouse power transformers. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

Oil Switches.—Bulletin AE-600. Describes a new line of Roller-Smith oil switches and circuit breakers and marking the entry of the company into this field. Roller-Smith Company, Smith Company, 12 Park Place, New York.

Electrically Operated Valves.—Bulletin 100, 4 pp. Describes electrically operated valves of the solenoid magnet type to control the flow of oil, water, gas, air, etc. Electric Valve Mfg. Co., 68 Murray Street, New York.

Lightning Arresters.—Bulletin GEA-93D, 8 pp. Describes G-E line-type lightning arresters, pellet oxide film, for application to a-c. circuits of voltages up to 50,000, for outdoor service only. General Electric Company, Schenectady, N. Y.

Bus and Cable Connectors.—Bulletin, 4 pp. Describes the application of Burndy connectors used for round and flat conductors in the Pennsylvania Railroad substation at Lamokin. This is part of the program for electrifying the main line of the Pennsylvania Railroad from New York to Wilmington. Burndy Engineering Co., Inc., 10 East 43rd St., New York.

Metal-Clad Switchgear.—Bulletin GEA-966A, 6 pp. Describes type MI-1 metal clad switchgear for indoor service, 400 to 3000 amperes at 7500 volts; 400 to 1600 amperes at 15,000 volts. General Electric Company, Schenectady, N. Y.

Motor and Factory Maintenance Equipment.—Catalog 12, 36 pp. Describes a line of commutator stones, grinding and turning tools, undercutters, paint sprayers, insulation meters, circuit testers, etc. The Martindale Electric Company, 1260 West 4th Street, Cincinnati, O.

Portable Power Units.—Bulletin 14-1000, 4 pp. Describes Century portable power units for farm applications, built in standard 3, 5 and 7½ horsepower sizes. Farm machines that are successfully operated by these units are listed. Century Electric Company, 1806 Pine Street, St. Louis, Mo.

Radio Continuity Tester.—Leaflet, supplement to Bulletin 300. Describes a new type of HTD radio continuity tester for making continuity and resistance tests on radio receiving and transmitting sets and on other radio devices and circuits. Roller-Smith Company, 12 Park Place, New York.

Electrical Fire Prevention. Bulletin, 16 pp., entitled "Killing Electrical Fires" and describing "Alfite," a system for extinguishing fires by carbon dioxide gas. The use of the new Westinghouse light relay, claimed to be the fastest known method for detecting fire and automatically actuating the "Alfite" system, is also outlined. American LaFrance & Foamite Corporation, Utica, N. Y.

Transformer Oil.—Bulletin 162, 8 pp. Describes Wagner transformer oil specifications originally prepared for their own organization only, but recently released for transformer buyers and users. Discusses the purposes of transformer oil, its properties, methods of testing, precautions when handling and storing. Wagner Electric Corporation, 6400 Plymouth Street, St. Louis, Mo.

Diverter Pole Generator.—Bulletin 94, 12 pp. Describes the use of the diverter pole generator for floating with bus control batteries. The advantages of the machine over a shunt-wound generator are outlined, and longer battery life is claimed for the diverter pole generator by reason of its maintaining automatically the correct charging rate. Rochester Electric Products Corp., 87 Allen Street, Rochester, N. Y.

NOTES OF THE INDUSTRY

The Kuhlman Electric Company, Bay City, Michigan, manufacturers of power, distribution and street lighting transformers, announces the appointment of S. L. Currier, 333 Union Trust Building, as representative in the Cincinnati territory.

Brown Instrument Company Enlarges Plant.—Due to the rapid growth of its business, new building of reinforced concrete, which will cost approximately $200,000, have been started by the Brown Instrument Company, Philadelphia. The floor space of the present plant will be increased 50% when the new construction is completed.

General Electric Reports Increased Business.—Orders received by the General Electric Company for the first quarter of 1929 amounted to $101,365,208, compared with $79,925,840 for the corresponding three months of last year, an increase of 27 per cent.

Delta-Star Expands.—Announcement has been made by H. W. Young, president of the Delta-Star Electric Company, Chicago, that the following additions to the manufacturing and distribution facilities have been effected.

The Champion Switch Company has been purchased and the Kenova, West Virginia plant will continue manufacturing its present line of equipment in addition to several new designs.

Manufacturing arrangements have been completed with the Societe D'Installations et de Constructions Electriques et Mecaniques, Boulogne-sur-Seine, to manufacture and distribute Delta-Star equipment in France and its colonies.

An interest has also been acquired in the Monarch Electric Limited, St. Johns, Quebec, which will soon be operated as the Monarch Delta-Star Company. At the Canadian factory will be manufactured a complete line of Delta-Star equipment—in addition to the present switching equipment, switchboards, oil circuit breakers and oil switches. New designs of large capacity oil breakers for voltages up to 132 kv. will be added shortly.

Delta-Star equipment will be handled by its established sales organization and the Kenova Champion works will be operated as a separate unit with its own sales organization. The St. Johns factory will handle all business for Canada and the British possessions and the French factory will have its own sales organization. Under the new arrangement domestic and foreign requirements can be met with an extensive line of air and oil break switching or substation equipment.

General Cable Corporation Appointed Agent for Copperweld.—The General Cable Corporation announces the consummation of an agency agreement with Copperweld Steel Company whereby General Cable Corporation is appointed the sole and exclusive agent in the United States to draw wire from Copperweld rods and to sell wire so drawn and wire products made therefrom.

Copperweld Steel Company has recently enlarged its special equipment for the production of Copperweld billets and rods and General Cable Corporation has, in its several plants, large capacity for the drawing of these rods into wire and for the fabrication of wire products. These complementary facilities, together with the engineering, sales and distribution organizations of both companies, will be effective to secure increased production and distribution of Copperweld wire and wire products, together with improved service to all users of Copperweld material.

Hereafter all copper covered steel wire and wire products handled by General Cable Corporation will be produced exclusively from Copperweld material. Full and complete sales and engineering service on Copperweld wire and wire products is now available through each of the Divisions of General Cable Corporation.

JOURNAL OF THE A I E E

DEVOTED TO THE ADVANCEMENT OF THE THEORY AND PRACTISE OF ELECTRICAL ENGINEERING AND THE ALLIED ARTS AND SCIENCES

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Vol. XLVIII JUNE, 1929 Number 6

Come to Swampscott!

THE Summer Convention of the Institute offers an opportunity for delightful fellowship with brother members, for hearing excellent technical papers, reports and discussions, and taking part, and for enjoying pleasurable recreation. But more—it also offers opportunity for advancing our profession still further.

The strength of the electrical engineering profession in America is reflected by the strength of our Institute. The more successful the Institute is in its service to the members, the higher will be the general standing reached by the profession.

The first day of the Convention is in many ways the most important day because then is held the conference of officers, Section delegates, and Branch Counselors. The subjects discussed at these conferences relate to means for making the Sections stronger, for increasing interest and service, and for cooperation between Sections and Branches; to questions pertaining to membership, to publications and other important matters.

This conference is not limited to the officers and the delegates. All members are invited, not only to attend, but to take part in the discussions.

While a program of subjects has been outlined by the committee, additional items of importance in the conduct of Institute affairs may be presented by anyone, as far as time permits. However, the outlined program covers a wide range of activities and interest.

Many of the Institute policies which are in effect today are the direct result of these Monday conferences, and judging from the wide interest evidenced on every side, this coming one will be no exception.

It is, therefore, hoped that all members who have given thought to the problems of the Institute, such as relate to Conventions, to Regional Meetings, to Sections or to Branches will attend the Monday meeting. The deliberations of that day will help to develop more traditions to enrich the Institute and will be a material factor in making our society advance to still greater heights of service.

R. F. Schuchardt

President.

Some Leaders of the A. I. E. E.

Severn D. Sprong, Manager of the Institute 1909-1912 and one of its Vice-Presidents 1912-14, is a native of Renssalaer County, New York. After completing the work of the common schools, he continued his studies for several years under special tutors. In 1893 he finished the General Electric Test and from then until 1898 served in various subordinate capacities in utility and special work. He then became Superintendent of the Electric Department of the Consolidated Gas Company of New Jersey at Long Branch, holding this position until 1900, when he was made Chief Engineer of the Central Electric Company, covering erection of central high-tension generating stations, transmission lines and four substations,—at Rahway, Perth Amboy, New Brunswick and Bound Brook,—replacing steam generating stations. Two years later he was chosen Assistant Chief Electrical Engineer of the New York Edison Company, remaining there until 1906, in responsible capacity engaged on the design of Waterside Station No. 2, numerous substations and transmission and distribution systems; also in the Williamsburgh Generating Station and several substations of the B. R. T. System, Brooklyn. From 1906 to 1909 he was associated with the design and construction of substations, transmission and distribution, and in charge of operations as Assistant Electrical Engineer for the United Electric Light & Power Company. Then for three years he was Chief Electrical and Mechanical Engineer for J. G. White & Company in charge of responsible direction of design and construction of numerous steam, hydro and transmission and distribution systems in the United States and Canada, also acting as advisor on various other projects along these lines. From the completion of this service until 1922 he was Chief Electrical Engineer for the Brooklyn Edison Company, in responsible charge of electrical engineering stations, substations, transmission and distribution, and all electrical construction of stations, substations, and street transmission and distribution; he was also in charge of the Meter Department and the purchase of all electrical machinery and equipment. From 1922 until 1925 he was Vice-President and General Manager of the Orange County Public Service Corporation, the Orange County Hydro Electric Corporation, Pike County Light & Power Company, and the Cape May Illuminating Company, in executive control of these properties including their development and operation, as well as the construction of hydroelectric plants. He was also President of the Port Jervis Traction Company during this period. This entire group of properties included also three gas plants and the distribution systems.

In 1922 Mr. Sprong established his own consulting engineering practise, acting at the same time as consulting engineer for the General Electric Company.

He became an Associate of the Institute in 1903 and was made a Fellow in 1912. From time to time he has been active on various Institute Committees and is at present on the Board of Examiners.

He holds membership in The American Society of Mechanical Engineers, is a member of the Society of Colonial Wars, and of the Sons of the Revolution. His clubs are the Crescent, Montauk, the Engineers and the Lawyers.

Technical Changes in Industry

The great advance made in recent years by central stations generating electric power in the more economical consumption of fuel per kilowatt-hour generated is emphasized in the survey of the National Bureau of Economic Research conducted for the Committee on Recent Economic Changes of the President's Unemployment Conference.

Data on central station efficiencies were gathered by L. P. Alford, who points out that central stations had succeeded in 1927 in reducing the consumption of fuel to 57 per cent of what it was in 1919 per unit of electrical energy generated. During that same period, the output of energy had more than doubled.

The advances in the design, construction, and operation of large steam central stations in the last decade have been principally along three lines; (1) larger generating units using steam turbines exclusively as prime movers, and larger boilers; (2) higher steam pressures and superheat temperatures; and (3) greater use of waste-heat recovery apparatus. To these may be added improvements in all auxiliary machinery to the advantage of the over-all efficiency of operation. A rough idea of the advance in efficiency may be had from the fact that for a station generating from 20,000 to 100,000 kilowatts, the present rate of coal consumption is about two pounds per kilowatt-hour as against 3.5 pounds per kilowatt-hour ten years ago. Heat economies have also been introduced all the way from the furnaces to the last expansion stage of the turbine.

Higher efficiencies than now obtained by the best, about 13,000 B. t. u. per kilowatt-hour or better than 26 per cent, are expected and can be produced; but not a great deal higher for the best all-round results.

Central station pressures are to be found in three ranges for modern installations; (1) a range around 400 pounds per square inch; (2) a range from 550 to 750 pounds; (3) a range from 1000 to 1400 pounds. The greatest activity at present is in the first and third ranges, the intermediate one being proportionately neglected. The choice between these two, the basis of selection, is partly a matter of load, but more a matter of coal price. For a cheap coal with a small average load, the 400 pound range is preferred; with a higher priced coal and a high average load the 1000 pound range is preferred; and usually we find both in the same station.

An Electrified Railway Substation
Of the Pennsylvania Railroad

BY J. V. B. DUER[1]
Associate, A. I. E. E.

Synopsis.—This paper contains a description of one of the outdoor substations of the Philadelphia-Wilmington electrification of the Pennsylvania Railroad, recently placed in service. It describes the initial installation of apparatus provided in the substation for the present suburban electrification, as well as the steps taken to accommodate the additional apparatus necessary for the through electrification when it takes place.

The location and control of the substation is described as well as the types of protective apparatus utilized and the method of operation. Attention is called to certain operating necessities which control the design and location of a substation of this character. The means provided for handling the heavy apparatus into and out of a substation of this character and the facilities for handling, cleaning and restoring oil to the different pieces of apparatus are described in some detail.

* * * * *

As a preliminary to this description, it is necessary to state that the Philadelphia-Wilmington electrification at its present stage of construction is designed for the multiple-unit suburban service only, but that everything has been so constructed that expansion to care for the handling of through electric locomotive hauled service, both passenger and freight, may be accomplished by adding to the existing facilities, without necessitating the replacement of existing electrical facilities. For complete electrification of main line territory, four single-phase 132-kv. transmission circuits

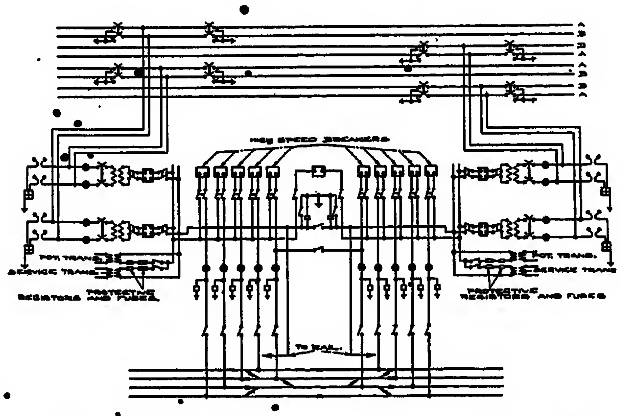

Fig. 1—Trolley Substation—Wiring Diagram

on two tower lines are proposed; with four step-down transformer units at each typical trolley supply substation. The initial installation, for multiple-unit service only, has required but two single-phase 132-kv. transmission circuits, each on its own supporting structures; and at each typical trolley supply substation, but two step-down transformer units.

It is then evident that the existing typical trolley supply substation is a structure which at present accommodates two single-phase transmission circuits, allowing for the sectionalization of each of these circuits by air-break motor-operated disconnecting switches. The structure further accommodates a tap from each of these transmission circuits, each of these two taps passing through another air-break motor-operated disconnecting switch to the high-voltage side of a 132/12-kv. step-down transformer, the tap being provided with choke coils and lightning arresters. The low-voltage side of each transformer unit is carried through a suitable two-pole oil switch and the requisite isolating switches to one section of a 12-kv. trolley bus. Ultimately, there will be four transmission circuits, four taps, (one from each circuit), and four transformers; but there will

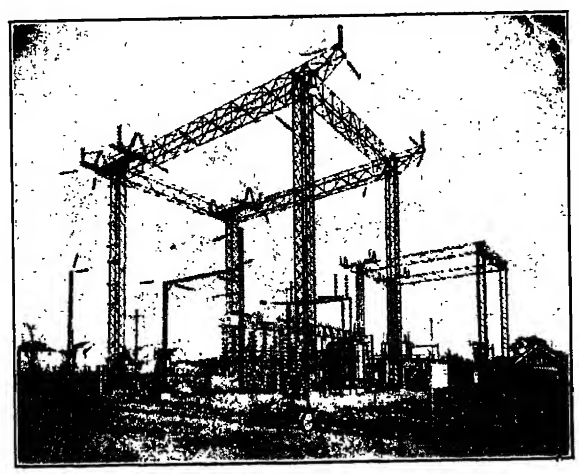

Fig. 2—Typical Trolley Supply Substation, General View

be only two trolley bus sections, as at present, each with two transformers connected to it instead of one.

Each bus section consists of a trolley and a rail bus. The two trolley bus sections are connected through a suitable single-pole breaker and the requisite isolating switches. The two rail bus sections are arranged so that they may be connected together through disconnecting switches, and further, so that either section or both may be connected to actual ground if desired.

1. Electrical Engineer, Pennsylvania Railroad Co., Philadelphia, Pa.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Printed complete herein.

From the trolley bus section, taps are taken, each of which pass through a single-pole high-speed trolley circuit breaker and the requisite isolating switches to a trolley. The trolleys passing by the substation are sectionalized so that those on one side are electrically separated from those on the other side of the substation. The trolley bus taps from one section of the trolley bus feed the trolleys on one side of the substation, and those from the other section of the trolley bus feed the trolleys

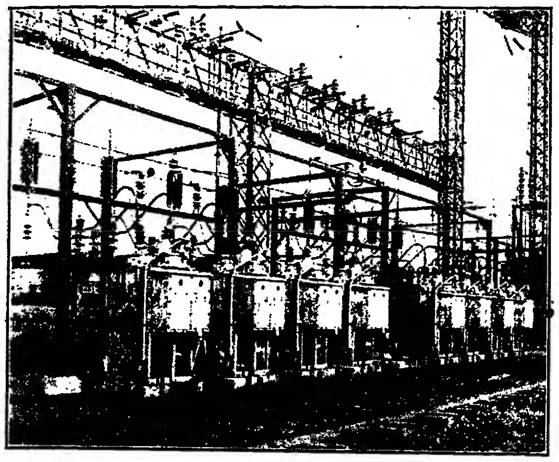

FIG. 3—TYPICAL TROLLEY SUPPLY SUBSTATION—TROLLEY BUS AND OIL CIRCUIT BREAKERS

on the other side of the substation. Each trolley bus tap is supplied with a choke coil and a lightning arrester and feeds into a different trolley from that fed by any other tap.

The railroad is equipped with interlocking cross-over

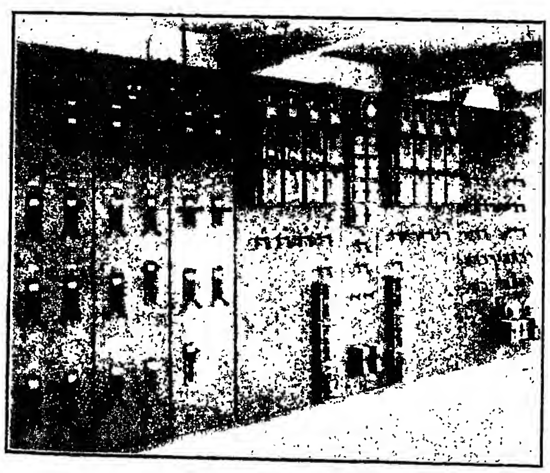

FIG. 4—TYPICAL SUBSTATION CONTROL BOARD IN CONTROL HOUSE

stations for the purpose of crossing traffic from one track to another at frequent intervals. These intervals are such that it is usually possible to locate the substations at certain of the interlocking cross-over stations. At one of these cross-over stations, the cross-overs between tracks are located between signal bridges, usually some 1200 to 2000 ft. apart. There is a signal and switch tower, more generally called an interlocking or block station, with an operator to control the cross-over movements. This tower is connected with the dispatcher's telephone circuit and with the emergency telegraph circuit. There are usually certain signal maintenance men working in the vicinity of the block station. If the telephone circuit of the load dispatcher or power director be run into the block station, and if the block station be equipped with a control board and the necessary signal lamps, the operator can well perform such substation switching operations as the power director may request, keeping the proper record of such operations. Further the operator can call by whistle or horn such signal maintenance man as may be within hearing and request him to perform such emergency operations within the substation as may become necessary prior to the arrival of a regular substation maintenance man. It is also evident that the trolleys covering the cross-over movements should be independently fed

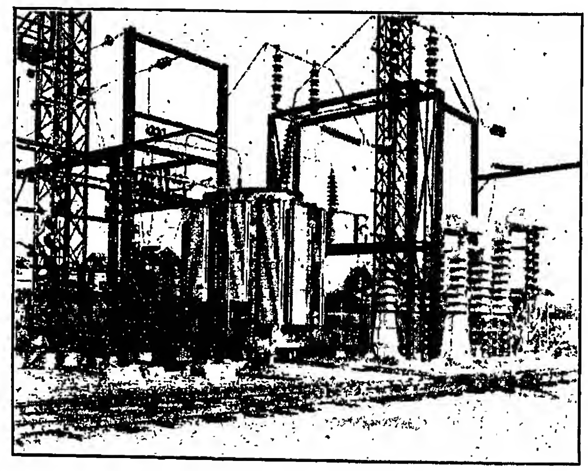

FIG. 5—TYPICAL TROLLEY SUPPLY SUBSTATION—4500-KV-A. TRANSFORMER

from those extending beyond, so that a dead trolley beyond will not hazard the making of a cross-over movement to another track to avoid the dead trolley. If the substation be located near the cross-over station, the cross-over trolleys may be readily fed independently, directly from the substation trolley bus sections. Cross-over stations not at substations require a special bus and switch arrangement to secure this independent cross-over trolley feed feature. We may state, therefore, that in so far as is possible, the typical trolley supply substation is located near a cross-over station and the substation switching operations are controlled from the block station by the block station operator under direction from the power director.

Within the fenced in enclosure of the substation is located a small control house. In this house there is located a control and relay board, a control battery and charging facilities, such signal supply motor-generator sets and switching as may be required, the substation oil treating plant with its purifiers, filters and valves,

and a telephone connected with the power director's circuit.

When the regular substation maintenance men are at work within the substation enclosure, by throwing a switch, they may take over the control of the substation switches from the block station operator's board to the control board in the control house. This operation is made upon direction from the power director and the block-station operator is informed and also receives a signal on his board when the control passes from his board to the control house board, or the reverse.

The entire relay layout for the station is on the control house board. All control operations and signals are at a control voltage of 125 volts, direct current supplied from the control battery. The control circuits are segregated for protection and for the easy location of grounds. Ground detecting apparatus is supplied.

In each substation are two service transformers, one on each section of the trolley bus, which give 230/115-volt, 25-cycle circuits from which the control battery is charged, the oil pumps operated, and the normal lighting obtained. A separate transformer supplies the signal motor-generator set or sets when such are installed at the substation.

Certain emergency lighting is supplied from the control battery.

Into each substation enclosure is run a railroad siding, and the apparatus is so located as to be readily loaded or unloaded to or from cars on this siding by a locomotive derrick or otherwise, as may be necessary.

The relay protection is such as to give the following protective functions:

Trolley high-speed breakers; high-speed impulse for short circuit; normal controlled speed relays for overload.

Each trolley bus section is differentially protected as to all breakers connected thereto for protection against bus faults.

Transformer Breakers; reverse power protection for transmission line-to-line faults; differential protection for transformer faults. Voltage relays for transmission line to ground faults supplied from a 66-kv. potential transformer connected from the midpoint of the high-tension winding of the main transformer to ground, the step-up transformers at the station supplying energy to the high-tension transmission having their midpoint grounded through resistance.

Buried oil tanks are provided in each substation for both transformer and switch oil. The piping system is such that breaker oil may be drawn from a dirty oil tank and purified and run into a clean oil tank and run into a breaker. The transformer oil may be run from the transformer through the purifier and back to the transformer, or from the transformer into the tank and thence through the purifier and back to the transformer.

The oil purifier is a combined centrifuge and filter with provision for by-passing either or both, the latter for use when oil is drawn from the clean oil tank and passed to a breaker.

The step-down transformers necessary in our eastern territory for the eventual complete electrification are of 4500-kv-a. normal continuous rating, immediately followed by 150 per cent load for two hours, immediately followed by 300 per cent load for five minutes. Thus, these transformers are much larger than normal commercially rated units of the same nominal continuous rating. They are self-cooled and self-protecting and every attempt has been made to insure serviceability. The number of these units installed initially and ultimately in a typical Philadelphia-Wilmington substation has been previously mentioned as two and four respectively.

The above describes the requirements of the substation layout. The actual physical structure which fulfills these requirements need not always be the same. It depends, naturally, upon the land available and upon other considerations which influence its design.

Typical views of a step-down transformer station are shown.

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

EXCERPTS FROM LETTERS OF APPRECIATION

May 28, 1928.

I appreciate the very efficient way in which employment problems are handled by you and beg to thank you for many kindnesses and courtesies in connection with the vacancies in this office.

May 28, 1928.

I want to express my appreciation of the effort that you made to locate the right man for this position and the discrimination that you showed in the applications that you sent me. I shall certainly bother you again when I have an opening as I believe you are doing a good service for our membership.

May 26, 1928.

We would not fail to comment on the high qualifications of all your applicants, and wish to thank you for the kind interest you have shown in this matter.

April 14, 1928.

We certainly appreciate your help and the high grade men you have referred to us. You may be interested to know that the only two men hired were applicants through your service, although we did receive some very good applications from our ad in a daily newspaper.

April 12, 1928.

We have employed Mr. .... to fill the position of Chief Engineer at ....

We appreciate keenly the assistance rendered by your organization and trust that we may find the means to reciprocate the courtesies you have extended.

Electrification of Oil Pipe Lines in the Southwest

BY D. H. LEVY[1]

Associate, A. I. E. E.

Synopsis.—This paper briefly reviews the history of electricity as motive power for oil pipe line operation and notes some of the reasons for, and the results of, its rapid development in the Southwest. Some attention is paid to the method of serving these loads from transmission lines and the tendency of modern pipe line practise is shown. The last five years have seen rapid advances in the methods of underground transportation of petroleum and the paper reviews some of the present tendencies in design of the modern oil pipe line station.

* * * * *

INTRODUCTION

During the last two decades, most of the crude oil produced in the United States has been moved to the refineries, ports, and markets through underground steel pipe lines. The oil was forced through these lines by means of reciprocating pumps driven by steam engines or oil engines.

About three years ago, a number of factors developed which allowed, and in fact required, the extensive employment of electric power for pipe line pumping and this system has now proved highly successful.

The chief factor in this adoption of electric drive was the recent discovery of vast quantities of oil in new fields in Texas and Oklahoma. This required immediate and quick construction and operation of more and larger pipe lines.

Electrical pumping was the solution for several reasons. The proposed pipe lines were to pass through rough and dry territory having few highways and fewer railroad facilities. This condition was favorable to the electrical equipment as it is lighter and more easily transported than Diesel or steam equipment. Furthermore, the available water was generally unsuitable for Diesel engine cooling. Steam for heating the oil was not necessary in the moderate climate in this region. Moreover, electrical equipment had given very satisfactory service in other applications in producing oil.

Considering all these conditions, one pipe line company electrified 150 mi. of 10-in. line and the results were very satisfactory. Later, when the immense Permian Basin fields in southwest Texas were discovered, electrical pumping was installed by several companies operating in that area.

One of the companies electrified 400 mi. of 10-in. line, extending from McCamey, Texas to Healdton, Oklahoma. This line is served by the transmission systems of three power companies and at this writing has been in successful operation for six months, meeting all expectations as to continuity of service and economy of operation. A second company built and electrified 125 mi. of line from McCamey to Del Rio, Texas with the same satisfactory results. A third company extended their lines from Crane through DeLeon, Texas to the Gulf, a distance of 650 mi. This line has 19 stations, 14 of which are completely electric-driven, and the remainder partially so. A fourth company has now under construction 450 mi. of 10-in. line with 11-motor-driven centrifugal pump stations and this line has been in operation since January 1, 1929.

The first pipe line company mentioned is now engaged in building a line from McCamey in West Texas to tide-water at Houston, a distance of approximately 425 mi. According to present information, this line is to be motor-driven.

In most of the cases a specially developed centrifugal pump is used. The centrifugal pump has the advantages of non-pulsating delivery, ability to handle oils of various viscosities, ideal characteristics for booster service, and low first cost.

Several years ago, before this type had been developed for oil-line pumping, the only available centrifugal pumps for the deliveries and heads required were boiler-feed pumps. These were tried and it became immediately evident that they were unsatisfactory. Pump efficiencies were 55-60 per cent and this alone precluded their use in oil line pumping. The centrifugal pump manufacturers attacked the problem from all angles and the so-called "high efficiency" type of multi-stage centrifugal pump came into being. New theories of centrifugal pump design were developed; casings and impellers were redesigned; internal losses were analyzed and reduced as far as possible and the mechanical details received much attention. Stuffing boxes and bearings were redesigned, and from it all, came the present oil line centrifugal pumps with higher efficiencies than had even been hoped for just a few years previously.

As to the electrical features of the typical motor-driven pipe line station, there is no departure from modern substation practises. A wiring diagram of a typical station is shown in the accompanying illustration (Fig. 1). Greater attention perhaps has been paid toward the construction of flame-proof installations. Some of the companies favor separating the motor from the pump by means of metal fire walls; others install

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them all in one room. It seems that personal opinion of the engineers of each company determines the policy to be pursued.

Squirrel-cage induction motors are used in all cases. Motors have been of all standard voltages but the present trend is toward the use of 2200 volts on all

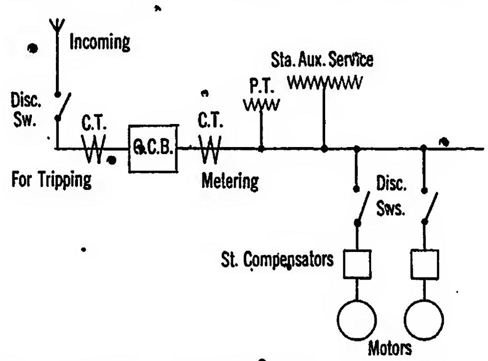

FIG. 1.—TYPICAL OIL PIPE LINE PUMP STATION

Oil line wiring diagram

motors above 50 hp. Oil circuit breakers are usually installed on incoming lines and these are provided with the usual overload, undervoltage, and over-pressure protection.

As to the actual cost of moving oil through pipe lines by means of electric power, it is impossible to give any accurate figures unless all the conditions of service are known. The various factors, such as efficiency of motors, efficiency of pumps, friction of station piping, rate schedules, discharge pressures, etc., all enter into the final analysis.

Below will be found a tabulation of electric pipe line station performance, based on crude oil of 80 Sec. Saybolt Universal viscosity at 60 deg. fahr. and at a discharge pressure of 700 lb. per sq. in.

PIPE LINE "A"
Reciprocating Pumps

Station	Months	Barrels pumped	Total kw-hr.	Barrels per kw-hr.
1	9	7,625,286	1,959,700	3.88
2	9	7,658,579	1,959,500	3.91
3	9	7,633,049	1,829,900	4.17
4	9	7,653,154	1,819,500	4.22

PIPE LINE "B"
Reciprocating Pumps

Station	Months	Barrels pumped	Total kw-hr.	Barrels per kw-hr.
5	6	4,756,768	1,202,900	3.96
6	10	6,538,992	1,684,000	3.98
7	6	4,480,040	1,122,600	4.05
8	10	6,519,459	1,616,100	4.03

PIPE LINE "C"
Centrifugal Pumps

Station	Months	Barrels pumped	Total kw-hr.	Barrels per kw-hr.
1	12	6,761,903	2,618,800	2.58
2	9	7,138,178	1,652,700	4.32
3	12	8,132,583	2,444,600	3.31

To meet the demands on their various generating stations and transmission systems, power companies serving the Southwest have had to make extensive additions, improvements, and extensions. Interconnections have been worked out and the service rendered has been, as a whole, very satisfactory to the pipe line companies.

In laying out transmission lines to serve pipe line loads, the importance of the absolute necessity to maintain continuous service must be considered. Pipe line systems having small ballast or surge tanks at each station do not provide storage capacity sufficient for an appreciable shut-down and a continuous supply of energy must be maintained at all times. To supply this demand, if at all possible, pipe line services should be supplied from a system having a two-way feed, with necessary switching apparatus to quickly sectionalize all transmission line faults.

As a source of constant revenue, pipe line loads are very desirable to the power companies. Revenues are the maximum on account of the high load factor. The average monthly load factor of one of the southwestern pipe lines for the last twelve months has been 86.6 per cent and from present indications it will continue as high for the next four years. These loads are desirable also on account of the ease of service. No extensive distribution facilities are necessary to secure the revenue. In many cases in Texas and Oklahoma, station locations are within sight of the transmission lines. As to the power factor of these loads, if the station is correctly designed, the motors driving the pump should be fully loaded and the power factor should be between 76 per cent and 87 per cent. Certain high-speed centrifugal pump motors, tested under field conditions, showed a power factor of 87 per cent. If the rate schedules contain a power factor clause with a penalty and premium rider, the use of condenser equipment by the pipe line company would be justified in most cases.

CONCLUSION

It is felt that the electrification of oil pipe lines is completely justified by the success of present installations. The time of installation is only half that required for Diesel engine equipment. The operators are easily trained to handle the electrical installations. Their operation on units of a transmission system having several sources of power is just as satisfactory as the present oil engine-driven stations. In general, shut-downs due to transmission line faults are less frequent than shut-downs due to failure of mechanical equipment. Cost of operation compares favorably with oil-engine driven stations. The near future will see many advances in pump construction and in electric pump station design and a consequent increase in over-all efficiencies.

Standard Voltage A-C. Network

BY JOHN ORAM[1]
Non-member

Synopsis.—The object of this paper is to present a description of the Dallas, (Texas,) underground network system. This system is of interest since it is directly opposed to the general trend of furnishing non-standard voltages in underground systems. The reasons for its selection and its advantages over the three-phase four-wire system are presented. A brief description of the installation of equipment in vaults and manholes is given. Another feature of this system is the use of standard reactance transformers together with an external reactor, shunted by a fuse, for purposes of overload protection to the transformers. In addition to the regular network this system has a single-wire manhole and vault lighting network which is also used as a control wire for turning on and off multiple street lamps. Another feature of this system is a complete underground telephone system with a telephone outlet in each manhole and transformer vault. This telephone system is also connected to float switches in transformer vaults which automatically notify the trouble office in the event of high water in a transformer vault. The routine tests made in connection with the operation of the network system are described and the method of locating primary faults is given in detail. Complete records are kept of the installation of conduit and cable. Photographic records of construction, operation, and cable failures, etc., are also kept. The record of this network system both as to efficiency and as to continuity of service is excellent.

* * * * *

THE principal characteristic of the Dallas, (Texas,) underground secondary network system is that it provides standard 115-volt service for lighting consumers and 230-volt three-phase service for power consumers. This is done by adding an 18-volt secondary coil to the standard 115-volt transformer coil and bringing out three leads on each transformer. With three transformers connected in "Y", the arrangement gives 115 volts for lighting and 230 volts for power service with a common symmetrically grounded neutral.

On account of the high primary voltage used and the relatively short distance of approximately one mile from generating station to load center no feeder regulators are required. The range of voltage regulation is about five per cent from no load to full load and the control of the generating station busbars by Tirrill regulators is adequate for this purpose. Since the major portion of the load follows quite closely that of the underground system and all other lighting service is controlled by individual feeder voltage regulators in substations, no interference with the remainder of the system is caused.

The Dallas network system covers an area of approximately 0.75 sq. mi. and consists of five 13-kv. underground feeders serving eighty-two 300-kv-a. transformer banks which supply two sets of secondary network cables, one being the lighting network and the other the power network. Automatic network units are used between transformers and the secondary network system. The principal load in the underground district consists of office buildings, theaters, department stores, and hotels. The average load density is 20,000 kv-a. per sq. mi. The greaest concentrated load is a hotel which consumes an average of 10,000-kv-a. hours every 24 hr.

The network system at present is designed for a normal maximum loading of 80 per cent on each transformer bank and an emergency loading of 100 per cent. This arrangement will permit the removal from service of any one of the five feeders without overloading the remainder of the system. The normal voltage in the secondary mains is 115 volts for lighting and 230 volts for power. The emergency voltage will average 110 and 220 volts for lighting and power, respectively.

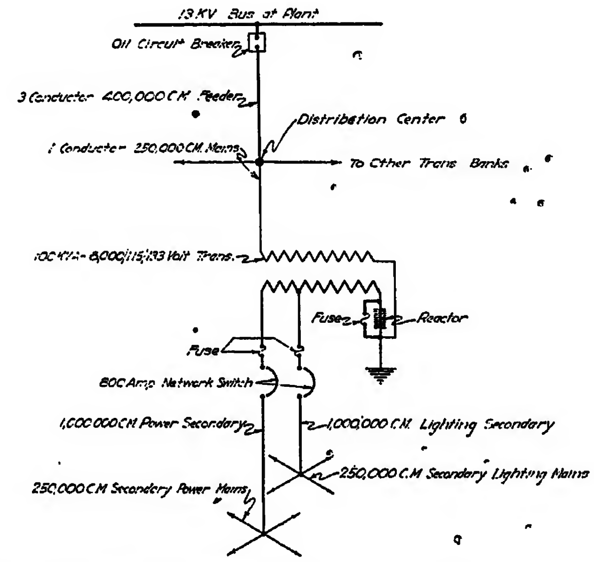

Fig. 1—Scheme of Design of Dallas Underground Network

The system is composed of three-conductor, 400,000-cir. mil 13-kv. primary feeders, 250,000-cir. mil 13-kv. primary mains, 100-kv-a. 8000-115/133-yolt transformers, automatic network units, 250,000-cir. mi lsecondary power cables, 250,000-cir. mil. secondary lighting cables, and a 500,000-cir. mil bare neutral.

The decision to use two sets of mains was made after a careful consideration of investment costs, operating costs and quality of service to be rendered. It was primarily because of the superior quality of service provided that the seven-wire system was adopted

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Previous to the installation of the underground network system the customers of the Dallas Power and Light Company had been furnished with standard 110-volt lighting and 220-volt power service. With the thought of good service and public relations in mind, some secondary network system was sought which would

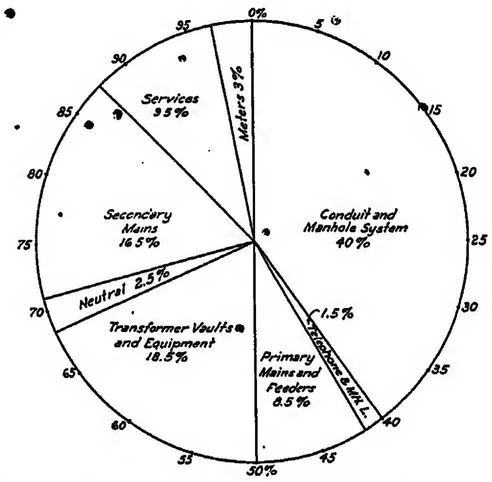

FIG. 2—CHART SHOWING DISTRIBUTION OF COSTS OF DALLAS UNDERGROUND NETWORK SYSTEM

continue to furnish normally standard voltages on both light and power mains. Investigation showed that the additional costs of the secondary portion of the system were offset by the better service provided and the saving in customers' equipment. Fig. 2 shows the comparative investment costs between the several major portions of the underground network system.

In addition to furnishing standard voltage to both lighting and power services the seven-wire system has the advantage that, since two separate sets of mains are used, fluctuations due to the power loads do not

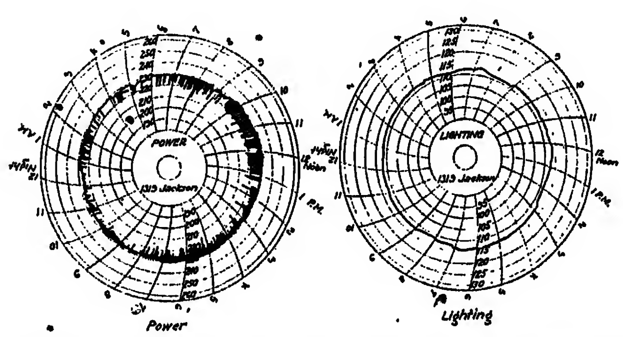

FIG. 3—TWENTY-FOUR HOUR VOLTAGE CHARTS ON POWER AND LIGHTING MAINS TAKEN AT SAME LOCATION

cause flickering of the lights. The absence of flicker on the lighting system may be observed from the voltmeter charts shown in Fig. 3, taken simultaneously on lighting and power services in the same distribution box. There is no limit to the size of motor that may be operated from the network system, and motors up to and including 30 hp. may be started directly across the line without the use of starting compensators. In this way the economy resulting from the simplicity, high performance, and balanced design of the common squirrel-cage motor is retained, together with greater flexibility in application where remote control is desired.

Another feature of this system is that standard reactance transformers are used with an external reactance installed in the neutral leg of each transformer, so arranged that the reactor is normally shunted by means of a fuse, thereby providing good regulation and lower secondary losses during normal operating conditions. When, however, an overload occurs on a transformer bank, due to feeder outage or other abnormal conditions, the fuses blow and thereby insert the external reactance in the circuit and relieve the transformer of part of its load.

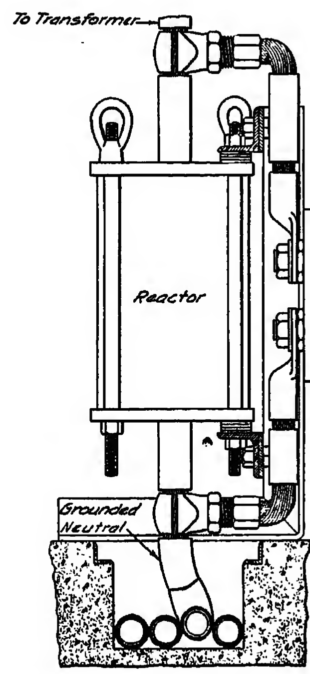

FIG. 4—FUSED REACTOR FOR TRANSFORMER PROTECTION

The transformers are installed in vaults either built by the Dallas Power and Light Company, or if in building basements they are in accordance with Dallas Power and Light Company specifications. In either case the only opening to the vault is through a manhole cover, 20 in. in diameter, built into a removable concrete panel 4 ft. wide, by 5 ft. long, placed in the sidewalk next to the curb. The castings in the panels allow men and small equipment to enter the vault with ease. If necessary to replace transformers or network switches the panel is removed. Each vault is ventilated by two 28-in. square ducts with openings in opposite ends of the vault, one near the ceiling, the other near the floor. Both ducts terminate on the sidewalk next to the curb and are covered with gratings.

The equipment in a transformer vault consists of three transformers, two network switches, primary

cables, secondary cables, three reactors, a condulet each for telephone and lighting service, and miscellaneous equipment such as a ladder, manhole guard, and covering for cable trenches. The primary cables enter the vault in one of the lower ducts and are racked on wall insulators to the transformers. The transformers are placed on T-rails imbedded in the concrete floor. The secondary leads are trained vertically from the transformer terminals to the secondary cable trench in the floor. The secondary power and lighting cables extend in separate trenches to the wall on which the network switches are installed. The 1,000,000-cir. mil secondary cables are extended from the upper

Fig. 5—Typical Double Transformer Vault

terminals on the network switch to the secondary network in the street. The secondary cables are racked separately from the primary cables.

There are at present 84 submersible and 80 non-submersible network switches in operation on the Dallas system. Of the submersible units 72 are solenoid operated and 12 motor operated; all use single-phase relays in air bells which are mounted on the wall of the vault. This arrangement facilitates maintenance and provides better ventilation of the relays. No phasing relays are used on the foregoing units. Of the non-submersible units 78 are solenoid operated equipped with single-phase relays and phasing relays, and two are motor operated equipped with three-phase relays and phasing relays. Few difficulties in the operation of the network switches have been encountered from unbalanced loads and elevator regeneration. These have been overcome by using three-phase relays or otherwise.

Although secondary network system in general consists of 250,000-cir. mil lead covered cables on cross streets or between important loads, additional 500,000-cir. mil cables are sometimes installed. The secondary neutral is grounded in each transformer vault and serves as a primary neutral.

The secondary services are extended to the customers building line in 4-in. fiber conduits, one each for power and lighting services where both are required. The conduits are terminated in a distribution box placed in the outside building wall, or iron conduit of reduced size is carried up the building wall about 12 ft. and terminated with a condulet. A panel is installed in the distribution box and both power and lighting services are connected to this panel. If it is not possible to install the distribution box, the customers' outlets are grouped on the outside wall at the first floor ceiling line. The cables used for services are single-conductor, 600-volt, paper insulated, and vary in size from No. 6 A. W. G. to 500,000 cir. mil.

In addition to the secondary and primary mains in the duct lines there are telephone and manhole lighting cables with outlets in each manhole and vault. The manhole lighting cables are No. 6 A. W. G. and form a secondary network with 115 volts to ground which is used by the workmen for lights, blowers, soldering pots, and other general conveniences. This network is connected to the main secondary lighting network through a fuse and switch, and is so arranged that in addition to serving as a manhole lighting system it will also serve as a pilot wire for controlling a proposed multiple street lighting system in the underground area.

The telephone system is in the same conduit as the manhole lighting cable. It consists of two 26-pair cables which extend from the switchboard in the Trouble Division's office to central locations, and branch out into two-conductor No. 14 lead covered cables. These two-conductor cables are installed on the main streets so that each manhole and vault has a telephone outlet.

The telephone system is also used as a signal system to give warning of water in transformer vaults. This is accomplished by connecting a coil of No. 4 bare copper wire in a porcelain housing to the ungrounded side of the telephone circuit. The device is installed in transformer vaults about six inches above the floor. When water reaches a level of six inches or more the telephone cable is short-circuited and a light signals the operator in the Trouble Office.

In the operation and maintenance of the network system certain routine tests and inspections are made. The vaults are inspected regularly and all dirt, paper, and other accumulations removed from the ventilator pits and floor. Oil samples from all transformers are taken once each month and tested for dielectric strength. The oil level in the transformers is observed and if necessary oil is added. The oil in each transformer is filtered at least once a year regardless of its dielectric strength. Each network switch is inspected weekly and the number of operations recorded. An inspection of network switches is made each month.

They are cleaned and adjusted, and repairs are made if necessary.

To test the operation of network switches, feeders are removed from service once each week during the light load period, by opening the circuit breakers at the Generating Station. If the feeder is not automatically deenergized when the breaker is opened, a trouble man is sent out to see which network switch has failed to open. A signal system installed in each vault saves the trouble man much time in locating the faulty switch. This signal system consists of a 125-volt lamp installed in the ventilator so that it can be seen by the trouble man without getting out of his car. One terminal of the lamp is connected to ground and the other to a lighting phase through an auxiliary switch that closes only when both network switches are open. A signal lamp not burning indicates that a network switch is closed. If faulty the switch is locked open until repaired.

In the location of primary faults special equipment is used. The apparatus is installed at the Generating Station and consists of a 50-kv-a. 440/8000-volt step-up transformer and 8000-volt, 15-ampere reactor. The procedure followed in locating a fault is to manually lock open each network unit on the feeder in trouble, disconnect the feeder at the Generating Station and connect the reactor to the faulty conductor until it is broken down to ground. With a split-core instrument transformer and low reading ammeter the current sent out over the cable is traced to the fault location.

Detailed records of underground installations are kept under five general classifications, *viz.*: (1) Duct Line Records, which are in the form of drawings showing a plan and profile of the duct lines together with the location of all substructures adjacent thereto; (2) Manhole Records, which are also drawings giving the location and details of construction of each manhole; (3) Cable Records, which give the location, size, date installed, and other data pertaining to each cable in each manhole; (4) Transformer Records, which gives the purchase specifications together with a complete history of each transformer; and (5) Service Records, which is a section map of the city showing the location and size of each lighting and each power service.

Records are kept of all equipment failures which includes a detailed description of the failure together with a photograph of the faulty apparatus where possible. Included in these records are cable failures, transformer failures, network unit failures, etc.

During the year 1928 the average efficiency of the underground network system, as calculated from watt-hour meter readings at the Generating Station and those on customers' premises, was 95.5 per cent. The average annual power factor was 0.90 and the load factor 0.50. Approximately 36 per cent of the energy distributed was power and 64 per cent lighting.

The operation of the system since its installation has been successful. The voltage regulation has been good and there have been practically no complaints. The record with reference to continuity of service, like that for voltage regulation, has been satisfactory. The completed network system has been in operation nearly two years and during that time no customer has been out of service. A number of faults on primary cables has occurred, but in each instance the trouble has been automatically and successfully cleared without interruption to service. Secondary cable faults burn clear without noticeable effect on the service.

STUDENT ENGINEERS SHOULD STUDY PSYCHOLOGY

Though an engineer now occupies the White House and the present is often referred to as the engineer's age, engineering graduates are earning small salaries. At the same time, the feeling of a lack of engineers all over the country persists.

Speaking about this puzzling situation, C. F. Kettering, general director of the General Motors Research Laboratories, stated in a recent talk before the Cleveland Section of the Society of Auomotive Engineers that engineering education fails to prepare the student for his real work because it does not teach him enough of economics and psychology. As a result, the young engineer cannot sell his ideas; he becomes discouraged and drifts into other lines of work where the rewards seem to be greater and more immediate. For instance, only 6 out of 37 graduates in electrical engineering in a single class were found to be practising electrical engineering 10 years after graduation.

To fit engineering graduates into industry, they should be put on a job that is similar to what they were studying in college, Mr. Kettering suggested, and be given a chance to become acclimated to industry and to assume a more important position.

Many engineers have not yet learned to use their imagination. We find in industry a question as to what the future demand will be, and the engineer should have enough imagination to see that the thing of tomorrow will be different from that of today.

Bankers, said Mr. Kettering, are interested in the engineer as never before, because they say that he is upsetting the stability of business, but the whole object of research is to keep everyone reasonably dissatisfied with what he has in order to keep the factory busy making new things.—*S. A. E. Journal.*

J. Tribot Laspière, director of the International Conference on Large Electric High-Tension Systems, which will hold its biennial meeting this year at Paris on June 6 to 15, reports that 380 members from 21 countries have already been enrolled. It is anticipated that the attendance of the 1927 session will be exceeded.

Abridgment of

Automatic Transformer Substations

Of the Edison Electric Illuminating Company of Boston

BY WILLIAM W. EDSON[1]

Member, A. I. E. E.

Synopsis:—The Edison Electric Illuminating Company of Boston has adopted a policy of numerous relatively small automatic a-c. substations located at the various individual load centers, this policy being enhanced by the development of a new method of automatic control and by the standardization of the station design.

The rating of a substation is based on the sum of three specially designed transformers each having an inherent 50 per cent overload capacity. Thus, the maximum load is normally carried by the three units operating at their nominal 100 per cent rating, but in emergencies the load can be handled by two banks, the transformer out of service, representing only 33 per cent of the station capacity instead of 50 per cent as in the usual case.

The automatic control consists essentially of load-current relays which switch in or out the follow-up transformers as needed. This operating point for maximum station efficiency equals $\sqrt{\dfrac{2 \times \text{core losses per bank}}{\text{copper losses}}}$. *Serious trouble on any bank will bring in the succeeding transformer. Each transformer has its own sequence switch so that it may be made leading, follow-up, second following, or manual, irrespective of the set-up for the remaining units. The simplicity of this control equipment is particularly interesting, in fact only the current control and one auxiliary relay are directly chargeable to the automatic control. The circuits and apparatus have several special features promoting safety and reliability.*

The construction of these stations has been standardized by the development of standard "blocks" complete in themselves and suitable for being arranged or added, as desired. Thus, for each transformer section there are four types of blocks—high-tension, low-tension, regulator and switchboard. Such an arrangement offers the advantages of complete segregation of equipment, flexibility in station layout, efficient provision for growth, standardization of engineering and construction, and the satisfactory use of complete bills of material.

This system of control and standardization of construction has been applied to five new automatic transformer substations in the last two years, and the results have been very satisfactory.

* * * * *

THE rapid growth and expansion of the electrical distribution system of The Edison Electric Illuminating Company of Boston has dictated a policy of numerous relatively small automatic a-c. substations located at the various individual load centers. Such an arrangement results in reduced line and feeder losses, better voltage regulation, improved reliability of service, closer balance between the load and the transformer capacity in service, and in a more efficient building program for the substations.

The value of this policy was materially enhanced by the development of a new method of automatic control which was much simpler in both design and operation than the previous schemes. In the last two years, the adoption of this control, along with the standardization of station design, has been applied to five new automatic transformer substations and the advantages are quite apparent.

Station Capacities

The ratings of these stations are based upon an ultimate of three units, and vary from 5000 to 15,000 kv-a. depending on local requirements, these differences being easily met by selection of the number and sizes of the transformers without detracting from the principles of standardization. Closely associated with this question of unit sizes is the special design of transformers developed some years ago for the Edison Company.

First of all, it is essential that a station be able to carry its full load in event of failure of one of the units. Formerly this contingency was met by installing the three transformers of such size that two at full rating could carry the load. This meant that under normal conditions one unit (50 per cent of station rating) and its switching equipment was out of service, which represents an economic loss.

Under the Edison Company's arrangement this situation is met by selecting a smaller size, such that all three would be used in carrying a full load. At a slight additional unit cost these transformers are given a 50 per cent overload capacity by increasing the copper and the cooling surface, so that if necessary any two could carry the full load without exceeding the normal 55 deg. cent. temperature rise. Of course the efficiency of these units would be reduced somewhat during this overload, but as this is an emergency condition the loss in kilowatt-hours is negligible.

Description of Station

For a 10,000-kv-a. station, for example, there are three 3500/5250-kv-a., three-phase, delta-star transformers having their maximum efficiency at 75 per cent (probable normal load) of their nominal rating of 3500 kv-a.; that is, at 2600 kv-a. Each bank has a high-tension bus section supplied by two 13,800-volt lines, these sections being connected by bus-tie breakers normally closed. The bank supplies a main and auxiliary bus having six 4000-volt, four-wire ungrounded neutral, regulated, automatic reclosing feeders. The low-tension bus-tie breakers are normally closed, but they trip automatically in case of a feeder fault if all

1. Station Engineering Dept., Edison Electric Illuminating Co. of Boston, Boston, Mass.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

three banks are in service, thereby, reducing the rupturing duty on the feeder oil circuit breaker.

Only two of these banks, however, are installed initially as the station load at first can be carried by one bank in an emergency.

Automatic Transformer Control Design

In designing the automatic operation of an automatic transformer substation the following procedure may be followed: (applies equally well to any type of automatic control)

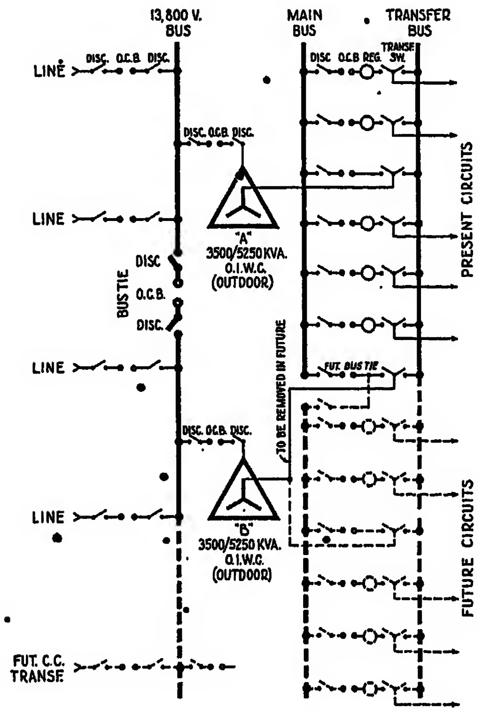

Fig. 1—Single-Line Diagram of Humboldt Avenue Station

1. The size and number of the various units and the one line diagram of the station are first established.

2. A list of the desired operating features is then discussed and agreed upon by the various interested departments of the company. Incidently, as for any type of automatic equipment, this is the real deciding factor leading to successful operation.

The equipment must be able to perform in general the duties of an operator in an accurate, safe and reliable manner, but there is a surprisingly large number of requirements which may safely be eliminated.

3. The third requisite in the designing of an automatic station is the collecting of the individual relay circuits into a combined diagram which is simple, efficient and safe. Three items must be kept in mind while studying this completed diagram.

a. Does it meet all of the operating features and control requirements?

b. Are there any short circuits or stray currents under any possible combination of relay or switch operations? Any amount of time spent on this study will be amply repaid when the set goes into operation. Even then, actual service will develop unexpected stray circuits, but these can be mitigated.

c. Can the installation be simplified, such as by assigning several duties to one relay, collecting various circuits to the same set of relay contacts, or by arranging the contacts so that the number of wires leading to an item of equipment is reduced to a minimum?

The schematic diagram is essential as each individual relay circuit can easily be followed and studied.

Some form of sequence chart is also of great help as it serves as a "slow motion" picture of the status at any operating step; that is, it shows the cause and result of each operation.

Operation

The system developed and adopted by the Edison Company performs as follows:

a. For light-load conditions, one transformer carries the load. As the load increases, the other banks cut-in automatically as required. The two properties available to control such operation are the transformer temperatures or the station load. The first is not entirely suitable as the temperature usually lags too far behind the load, it is not independent of the weather conditions, and the present temperature relays are somewhat delicate and difficult to keep in adjustment.

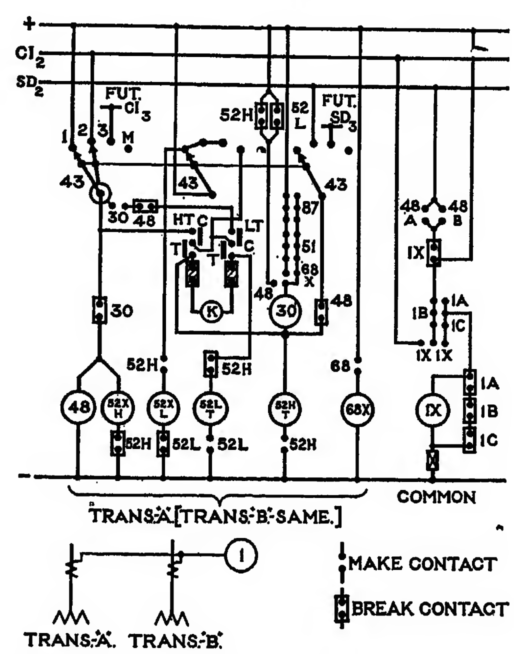

Fig. 2—Schematic Diagram of Transformer Control

The second method (station load) offers better results as the current relays already developed are quite accurate and reliable. Another important advantage is that the transformers can be operated nearer the best over-all efficient point. For example, these cut-in relays can be set at a point where the core and copper losses of one transformer equal the total losses of two transformers. Expressed mathematically this most efficient point

to bring in the second bank equals $\sqrt{\frac{2\ L_i}{L_c}}$ where L_i is the core or zero load losses of one transformer and L_c is its full load copper losses.[2] This point averages

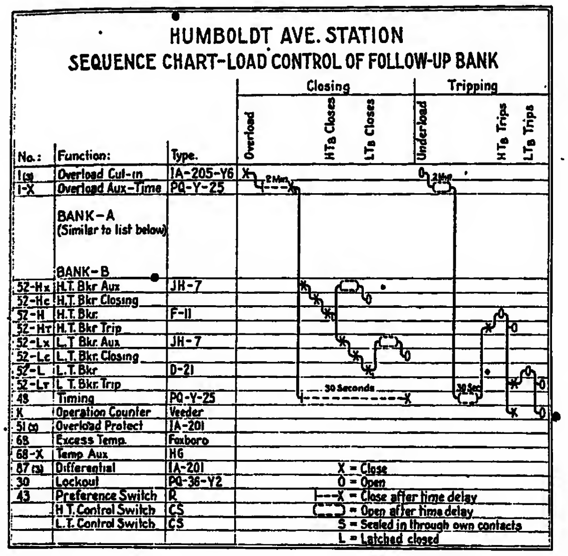

FIG. 3—SEQUENCE CHART—AUTOMATIC STARTING

approximately 105 per cent of the nominal rating (70 per cent of total) for the transformer used, which means the banks are always cool and available for unusual demands.[2] Since there is little occasion for the transformers to be overloaded (which often occurs with temperature control) the voltage regulation is materially improved.

The relays used for this control (one in each phase) are the G. E. Type IA, the overload contacts being connected in parallel and the underload, or back contacts, being in series. The latter operate at about 90 per cent of the cut-in value. An auxiliary timing relay, Type PQ set for two minutes is used to prevent too frequent operation on a surging load and to reduce the wear on the contacts of the current relays.

In case of overload the cut-in bus is energized, which will bring in any bank or banks whose preference switch is connected to this bus. The auxiliary closing contactor is energized and the high-tension oil circuit breaker closes, which in turn sets up the closing circuit for the low-tension breaker. It will be noticed that when the cut-in bus was energized the protective timing relay No. 48 began to close. By the time it completes its stroke, the high- and low-tension breakers should be closed but if not, or if one drops out due to latch trouble, a tripping circuit is set up and the transformer is locked out.

When the station load decreases the shut-down bus is energized. At the same time the cut-in bus is deenergized which allows No. 48 timing relay to open. When it completes its operation the tripping circuit for the high-tension breaker is completed and this breaker opens, followed in turn by the low-tension breaker.

A similar set-up would be used to control the third bank through a second set of cut-in and shut-down busses.

b. The question of safety and reliability assumes special importance in a non-attendant station. These are met in the Edison system by providing each transformer with differential protection relays, excess overload relays, maximum oil temperature relays and an over-all checking relay to insure that the circuit breakers do not drop open or pump. Any of these faults operate the lock-out relay No. 30 and trips both breakers.

There are also several inherent features of design which promote safety; such as, only one polarity is taken to the circuit breaker auxiliary switches or to the relay contacts, all relay coils are for continuous duty, no contacts are subjected to unsafe carrying or breaking currents, interlocks are included to make the high-tension breaker close or open before the low-tension breaker, thereby reducing high-tension voltage stresses, the various circuits are arranged so that improper operation of set-up or manual control switches cannot do any harm, and the number of relays is reduced to a minimum.

c. A second operating requirement calls for the

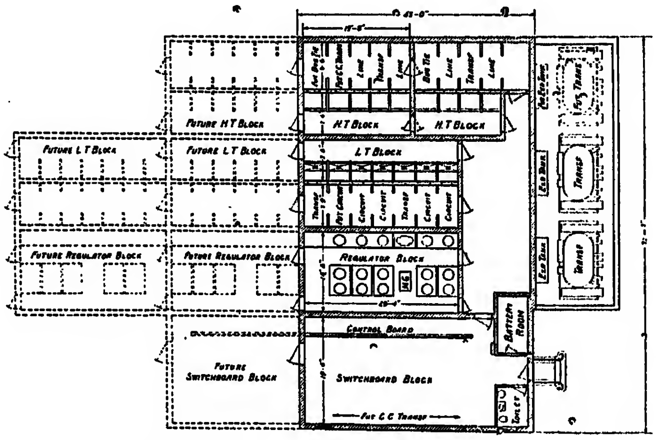

FIG. 4—PLAN OF HUMBOLDT AVENUE STATION

transfer of load to another transformer in case one of the banks is in trouble. This is accomplished by energizing one of the above mentioned cut-in busses by means of the transformer lock-out relay. Here again time is introduced (approximately 30 sec.) before the alternate bank restores the system for the same reasons that timing is used on the automatic reclosing breakers on the low-tension circuits.

Lock-out relay No. 30 removes potential from relay No. 48 which after a time delay drops open. This completes the circuit through the preference switch to energize the cut-in bus which will bring in the next transformer in a similar manner as above.

2. See appendix, complete paper.

d. Full selectivity is provided by giving each transformer its own sequence switch so that any bank may be made first, leading; second, follow-up; third, alternate; fourth, out. Manual control switches are connected to this fourth position as a matter of uniformty in operation between stations otherwise they could be omitted. It will be noted that any of the transformers can be operated independently of the others. For example, one may be under manual control and the rest automatic, or if desired, two may be set up to operate in parallel as a group thereby permitting two smaller banks to operate as a unit and reducing the number of operating cycles.

1. A high-tension block for the two incoming lines, the 13,800-volt bus and its tie breaker, and the transformer high-tension breaker.

2. A low-tension block for the transformer low-tension breaker, the main and transfer busses with their breakers and disconnects, and the 4000-volt feeders.

3. A regulator block for the feeder induction voltage regulators. The battery motor-generator set and the station power and lighting transformers are located in the space opposite the bus-tie cell.

4. A switchboard block for the control switchboard, battery room, toilet, and the constant current lighting transformers if used.

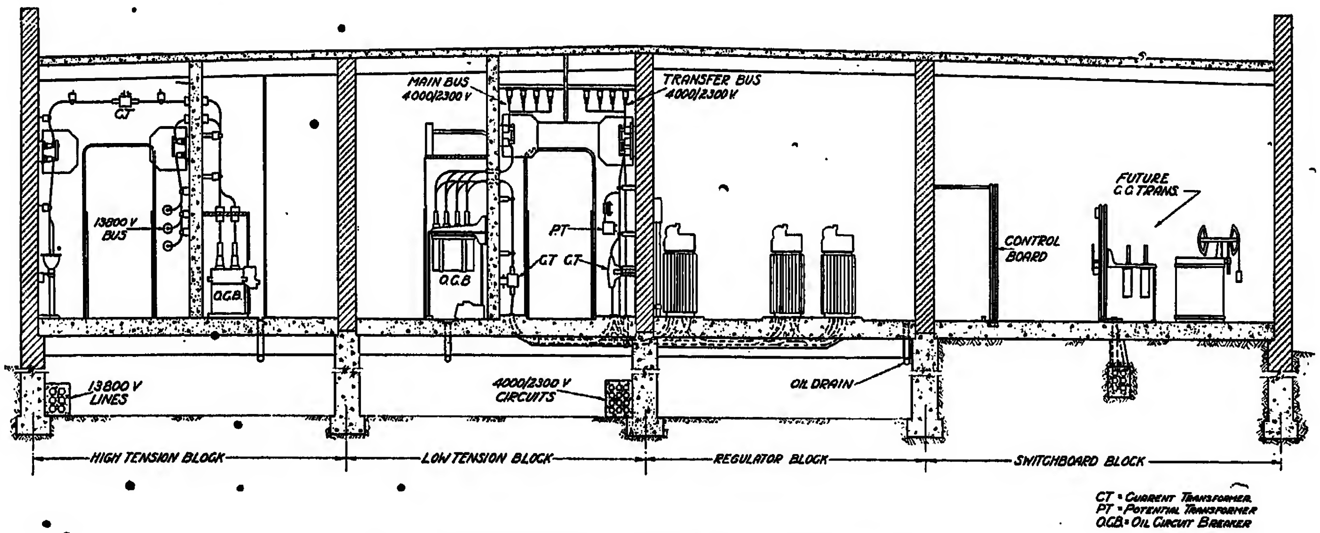

Fig. 5—Cross-Section of Humboldt Avenue Station

Miscellaneous Automatic Features

The manufacturer's method of automatically reclosing feeder circuit breakers has been revised somewhat to include the safety features and simplicity referred to above.

The battery charging motor-generator normally floats on the control battery, but it will shut down in case of certain faults and will restart when conditions become normal.

A signal is sent over leased telephone wires to the nearest manually controlled station to indicate the opening of any line or feeder circuit breaker, the lockout of any transformer, or a ground on the 4000-volt system. This latter indication is accomplished by means of a CV voltage relay connected between the system neutral and ground.

Station Design

The construction of these automatic substations has been standardized as far as practicable. The basic feature which permits this standardization of construction is that the station is divided into "blocks," complete in themselves and suitable for being arranged or added as desired.

For each transformer section there are four such blocks:

Advantages of the Block Design

a. Complete segregation, the blocks themselves forming natural fireproof subdivisions.

b. Flexibility in arrangement to meet land or neighborhood conditions.

c. Efficient provision for the growth of the station by the addition of blocks as needed.

d. Standardization of construction, resulting in the simplification of the preliminary load, land and cost estimates as similar information from previous stations is at hand, the betterment of the price and delivery for the purchase of the equipment due to duplication of former orders, and the decrease in the time and cost of the design installation and operation of the station. Incidently, it is an advantage to know in advance that the completed station and its operation will be satisfactory to the various departments concerned as the individual standards have already been tried in service and approved.

e. Satisfactory use of an itemized bill of material, this list being grouped in accordance with the station blocks and giving such information as may be needed during the various stages of engineering or construction.

Miscellaneous Construction Features

Each high- and low-tension block is divided by an

eight-inch concrete fireproof wall so that the oil circuit breakers are in one compartment while the busses disconnects and instrument transformers are in the other. Metal lath and plaster cell walls two inches thick separate the equipment per circuit. The regulator room and breaker cells are drained to prevent spreading of any possible burning oil. There is no reinforcement or other steel work carried over between cells. The ground busses are run on insulators to prevent fault currents passing through the structure.

The cell wiring is flame-proof varnished cambric cable. The high- and low-tension cables running to the outdoor transformers have oil-filled potheads to prevent leakage of oil from the transformers which are of the "industrial" oil pothead entrance type. This latter construction eliminates all outdoor structure.

An individual ventilating fan is provided for each compartment so that any room can be quickly cleared of smoke or gases after a fire.

Individual automatic electric heating units with circulating fans are installed in each room for general heating and for preventing condensation.

The general illumination is by alternating current, but floodlights and certain lighting circuits are on a manually operated change-over switch to the battery for emergency use.

Figs. 1, 2, 3, 4 and 5 apply to the Humboldt Avenue automatic substation but the other four stations follow the same general design except for variations in assembly of the "blocks." For example in the Arlington Substation the switchboard and regulator blocks are located on the second floor.

The construction and operation of these stations have been very satisfactory and it is expected that this type of design will be continued in future stations.

Abridgment of

Guarding and Shielding for Dielectric Loss* Measurements on Short Lengths of High-Tension Power Cable

BY E. H. SALTER[1]

Associate, A. I. E. E.

Synopsis.—This paper presents the results of investigations made to explain the wide differences found between dielectric loss measurements made on full-reel lengths of cable and on samples (10 ft. net length) removed from these reels. At least one source of such differences is found in losses occurring at the ends of the cable, these losses being insignificant in the case of the full reel but amounting to as much as 100 per cent of the loss in the normal sample. Methods of determining, controlling and eliminating these end losses are described.

* * * * *

Introduction

WITH the advent of low-loss insulations, it has become necessary to make measurements of dielectric loss and power factor of power cables with greater accuracy and refinement. Since a large proportion of the measurements of this nature are made on comparatively short lengths of cable (10 ft. net length under sheath), the question has often been raised as to what influence the end conditions in these specimens might have on the results obtained.

General

At the Regional Meeting held in Pittsfield, Mass., May 25-28, 1927, Mr. C. L. Kasson presented a paper entitled *High-Voltage Measurements on Cables and Insulators*[2] in which he pointed out that in measurements with high continuous potentials and high single-phase alternating potentials, very large errors might occur due to corona formation at the cable ends and on the lead wires. He showed how, by complete electrostatic shielding and guarding of the sample under test and the instrument circuit, these losses might be eliminated from the measurements.

Such shields and guards have been in use for some years in laboratories making dielectric loss and power-factor measurements on short lengths of cable, where, to accomplish this end, it has been the practise to use the tank of the supply transformer as a shield for the transformer, to use lead-covered power cable for high-voltage leads wherever practicable, to screen the cable sample (and the air condenser, when used) and to use shields on all leads to the measuring instruments, these shields often surrounding the instruments as well. The proper use of such precautions eliminates practically all effects due to direct leakage (conductance leakage) and to capacitance connections between high- and low-voltage circuits. All of the above mentioned have to do chiefly with the equipment for making dielectric loss measurements. It is the purpose of this

*Part 4 of a Symposium of six papers on Shielding in Electrical Measurements.

1. Engineer, Cable Research, Electrical Testing Laboratories, New York, N. Y.

2. A. I. E. E., TRANS., Vol. XLVI, 1927, p. 635.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

paper to discuss certain conditions relative to the samples, as such, which have been found to play a large part in the results obtained in these measurements.

In test work, power cables fall into two general classifications; *i. e.,* single-conductor cable and multi-conductor cable. For power service, most multi-conductor cable is three-conductor. There are then two general types of three-conductor cable, according to construction; *i. e.,* the belted type and the shielded-conductor type. Each of these three groups represents a slightly different problem in preparation for test. They will be dealt with here in the order named.

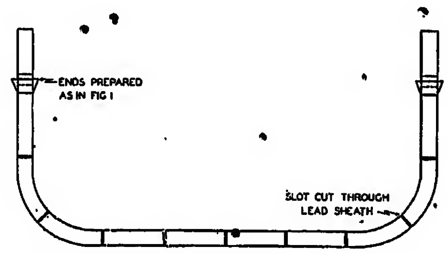

FIG. 2—DISTRIBUTION OF SECTIONS FOR POWER-FACTOR SURVEY ALONG NORMAL SAMPLE

Guarding the Single-Conductor Test Specimen. Tests on a number of samples in which lead sheath was slotted at 1-ft. intervals throughout its length, as shown in Fig. 2, showed the end sections to have extremely high power factor and ionization factor. This condition, while not always serious before heating the sample, was found to be quite pronounced after heating to 100 deg. cent. and cooling to room temperature. This condition is illustrated by Figs. 4 and 6 showing the results of tests at room temperature before and after heating to 100 deg. cent.

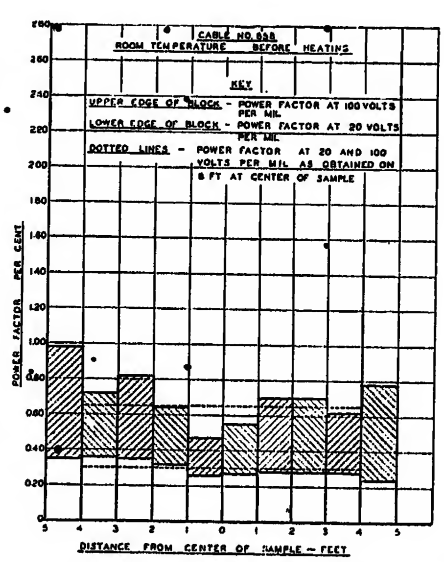

FIG. 4—SINGLE-PHASE DIELECTRIC LOSS MEASUREMENTS

Power-factor variation along length of cable

It will be noted from Figs. 4 and 6 that the 1-ft. sections at the ends of the specimen are for the most part the only ones showing any considerable change in power factor. In these end sections, the impregnating compound is, to a certain extent, open to the air so that the increases found are likely due to air absorption with possible oxidation of the compound while at the higher test temperatures.

The method of eliminating these end losses from measurements on a length of cable is almost self-evident in an examination of the results shown; *i. e.,* eliminate these 1-ft. sections at the ends from the test circuit by making them a part of the guard or shield circuits. This, then, means that in preparing such a sample for dielectric loss tests, circumferential slots are cut through the lead sheath at least 12 in. from each end. These slots are filled with insulation and sealed against loss of oil when the cable is heated. The central section of lead sheath then forms the test electrode while the isolated sections at the ends are used as guards.

Guarding the Belted Three-Conductor Test Specimen.

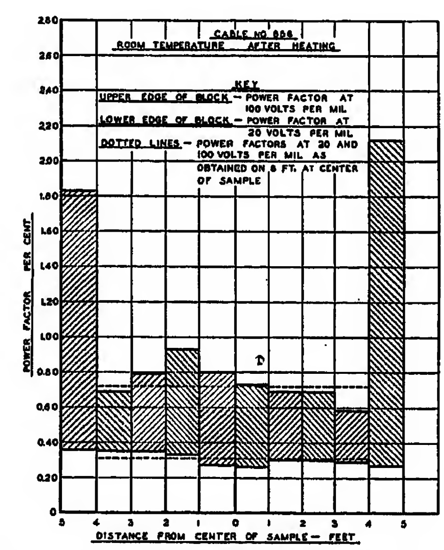

FIG. 6—SINGLE-PHASE DIELECTRIC LOSS MEASUREMENTS

Power-factor variation along length of cable

Dielectric loss tests may be made on three-conductor cable with either three-phase potential, obtaining the loss directly, or with single-phase potential, computing the loss from the results of a series of tests. While the tests described below were all made with three-phase potential, it is felt that the findings are equally applicable to tests made with single-phase potential.

In addition to end losses of the type found in the single-conductor cable, and which it is felt must likewise be found in the three-conductor cable, there is the loss due to the inter-phase capacitance of the end connections. This loss has become increasingly significant, particularly in the case of the higher-voltage cables where ionization of the air in the crotch space of the cable gives visible signs of the loss in the form of corona.

In order to determine the magnitude of these crotch losses and to find the most effective method of pre-

paring the ends of specimens to render these losses negligible, a series of specimens was prepared and tested as follows:

A. With the ends prepared as shown in Fig. 7.

B. With the cambric joints and cable ends covered with metal foil down to the old band guards.

C. With the belt insulation cut back even with the end of the lead sheath and the guards used in B extended all the way down into the crotch.

D. With a sheet metal guard, about four inches long, placed around each conductor and well down in the crotch space.

The results of measurements under the above conditions are shown in Fig. 12. Apparently, shielding against corona loss in the crotch space (the four inches adjacent to the end of the sheath) reduces these end losses to a point where their significance in commercial measurements is negligible.

Guarding the Shielded Three-Conductor Test Specimen. The problem of guarding the ends of the short specimen of shielded three-conductor cable is much the same as that of guarding the ends of the belted three-conductor cable. In both cases the problem is to prevent corona formation in the crotch and to reduce the loss between conductors. The studies of end conditions in the shielded conductor cable followed much the same lines as the studies of the belted cable. Due to the type of construction, the crotch losses are much more readily controlled, however.

Conclusions

The investigations of end losses in dielectric loss tests of short specimens of high-tension power cable

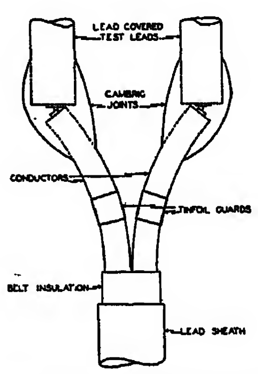

Fig. 7—A Method for Testing Crotch Losses

appear to indicate that the most satisfactory methods of minimizing these end effects are to be found in the following methods of preparing the test ends.

1. Single-conductor cable is most effectively guarded against end losses by isolating about 12 in. of cable at each end of the specimen for use as guards. When making temperature runs, the slots in the lead sheath incident to this preparation must be filled with insulation and sealed against oil leakage. The best slot width is approximately 1/8 in., narrower slots being difficult to maintain and wider slots affecting the loss measurements due to the fringing field from the slot edges.

2. Three-conductor belted type cable is practically free from corona loss in the ends if the samples are prepared with the belt insulation cut off even with the sheath end and guards 4 to 6 in. long are placed well down in the crotch. For most effective placing of the guards, it is advisable to make them of tin-plate or some similar stiff material which can be driven down into the crotch. A thin layer of varnished cambric

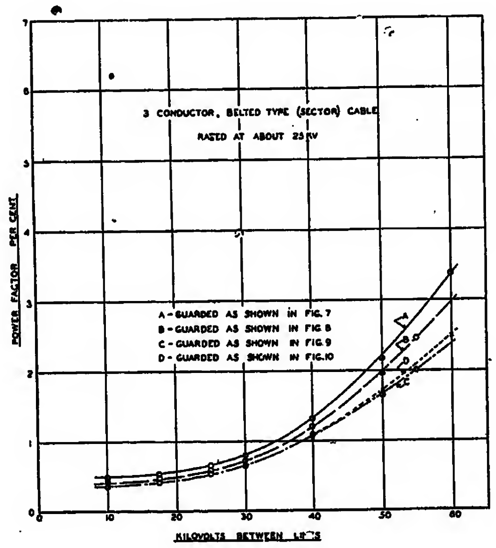

Fig. 12—Variations of Power Factor with Voltage

placed over the guards before inserting serves to insulate them one from the other.

3. The simplest scheme of preventing crotch losses in the shielded three-conductor cable is to leave the metal-foil on the individual conductors beyond the crotch space, a matter of 4 to 6 in. Narrow band guards placed above the ends of the metal foil then take care of surface leakage.

RADIO PERMITS TALKING FROM MOVING TRAIN

A new method of radio-telephonic conversation between a moving train and a stationary instrument is announced from Canada, where it has been successfully carried out on the Canadian National Railway lines. The new device throws the voice from the train to the telegraph wires which line the right-of-way of every railroad. It is then carried to the terminal point and there connected with the ordinary telephone lines. This process is reversed as regards the other participant in the conversation. As the system now stands, the terminal points must be not more than about 150 miles apart or the voice is lost. A two-hour conversation was held in this way on May 5, and several points of advantage over the German system are claimed. Experiments in perfecting the system were carried on by J. C. Burkholder, formerly with the Bell laboratory at Newark, N. J.—*Electrical World.*

Abridgment of

Precautions Against Stray-Field Errors in Measurements with Large Alternating Currents*

BY FRANCIS B. SILSBEE†
Member, A. I. E. E.

Synopsis.—*In electric power stations it is often necessary to make accurate measurements of current or power when the instruments are located near to the cables carrying large alternating currents. The magnetic field produced by these currents may constitute a serious source of error in the measurements unless careful precautions are taken to guard against such disturbing effects. This paper summarizes the various principles and methods for detecting and minimizing the errors which may arise from this source. The principal methods are: (1) To so arrange the cables carrying the large currents that they produce as little stray magnetic effect as possible; (2) to use instruments of the shielded or of the astatic type; (3) to repeat readings with the instrument connections reversed; and (4) to avoid all loops in the connecting leads.*

* * * * *

I. Introduction

It often becomes necessary in the central station or the laboratory to make precise electrical measurements with apparatus which is unavoidably located near conductors which are carrying large alternating currents. The magnetic field produced by such currents may become a source of serious error in the measurements, either because of the direct effect of the magnetic field in adding a ponderomotive force to the moving element of the instrument used in the measurement, or because of the electromotive forces induced in the measuring circuits by the alternating magnetic field.

It is the purpose of this paper to summarize the various principles and methods which have been suggested for detecting or minimizing the errors which may arise from the presence of stray alternating fields. This treatment, however, will be limited to those methods which are applicable in the range of frequencies used in power generation and distribution, though many of these are also applicable to audio- and even radio-frequency measurements.

The more important methods are (1) proper arrangement of the conductors carrying the large current, (2) proper choice and arrangement of measuring apparatus, (3) repetition of readings with reversed connections, and (4) proper location of connecting leads. These methods will be discussed in order.

It should be emphasized that no one of them constitutes a panacea for all stray-field troubles but that the obtaining of correct results usually requires the judicious application of several of these principles.

II. Arrangement of Current-Carrying Parts

Whenever it is possible to do so, the conductors carrying the heavy currents should be so placed as to minimize the stray field which they produce. While exact computations of the field produced by various possible arrangements are both difficult amd unnecessary, it is often desirable to obtain a rough estimate of such fields, for instance in judging the relative merits of two alternative conductor arrangements. Such estimates may be based on the following approximate relations.

The field at a point P, a considerable distance from a flat loop of cable, is roughly $H = \frac{0.2\,A\,I\,N}{D^3}$, where H is the field strength in gausses, $I\,N$ is the ampere-turns in the loop, A is the area of the loop in sq. cm. and D is the distance in cm. from the center of the loop to the point P. When the point P lies near the axis of the loop or in the plane of the loop the direction of the magnetic field is parallel to the axis of the loop. At points which lie in other positions with respect to the loop, the direction of the field is of course quite different but can be estimated by reference to a sketch of the lines of force around such a loop (*e. g.*, Fig. XVIII in Maxwell, Electricity and Magnetism, Vol. 2, 3rd edition).

The field caused by a long straight conductor carrying a current which returns at a great distance is $H = \frac{0.2\,I}{D}$ and obviously drops off much less rapidly with distance than that caused by a loop. The lines of force are everywhere perpendicular to the conductor and to the line joining the point considered to the nearest point on the conductor.

Fortunately, however, the return circuit is usually not very distant. If two long straight conductors are at a distance g apart, the field H at a point P located at a considerable distance D (measured from a line midway between the conductors) is $H = \frac{0.2\,I\,g}{D^2}$. The magnitude of the field for a constant distance D is nearly independent of the location of P with respect to the plane containing the two conductors, although, as in the case of a loop, its direction varies greatly from

*Part 5 of a Symposium of six papers on Shielding in Electrical Measurements.

†Physicist, Bureau of Standards.

Publication approved by the Director of the Bureau of Standards, Department of Commerce.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

point to point. Since the stray field is proportional to the spacing g, it is very desirable to make this as small as possible. When the conductor section must be large it is well to use thin strips or slabs placed close together. The effective spacing g is then approximately the distance between center lines of the slabs and may be made much less than the width of the slabs or the diameter of a circular rod of the same conductance. This arrangement has the further advantage of minimizing the self-inductance of the circuit and hence lessens the reactive volt-ampere capacity of the apparatus required for supplying large currents for testing purposes. In the equipment recently installed at the Bureau of Standards for current transformer testing bars 20 in. by ½ in. have been used.

From the point of view of minimizing stray fields the ideal construction for the heavy conductors is to use a pair of coaxial cylinders. Such a return circuit produces no magnetic field at points outside the outer tube, provided the current distribution is symmetrical about the common axis of the cylinders. While this form of construction has been used to some extent in shunts[2] and certain types of instrument,[3] it tends to introduce considerable mechanical difficulty especially in arranging terminal connections.

It is not generally appreciated how closely the ideal concentric construction can be simulated by subdividing the conductor and placing its parts symmetrically around the other bar. If the return conductor consists of four wires connected in parallel placed 90 deg. apart around the central outgoing conductor and at a distance g from it, the field at a distance D from the central rod has the value $H = 0.2\ I\ g^4/D^5$. The direction of the field is tangential at positions which are on lines drawn through the central rod and each of the returns and is also tangential but in the reversed sense at positions on lines making 45 deg. with these axes. The direction of the field is radial at positions on lines making an angle of 22.5 deg. with the axis. When D is as great as 10 g, the stray field with this arrangement is only one one-thousandth as great as that caused by an ordinary two-wire circuit with the same spacing.

Table I summarizes the formulas given in the preceding paragraphs and indicates by the numerical values computed for a typical case the magnitude of the stray field to be expected.

An unshielded electrodynamic wattmeter can be used to detect and measure stray magnetic fields by applying rated voltage to the moving coil circuit while the current circuit is left open. When the orientation of the instrument and the phase of the applied voltage have been adjusted to give a maximum deflection, this deflection is proportional to the stray field present at the point where the wattmeter is located. The instrument may be calibrated by placing it at the center of a loop of large radius (R centimeters) carrying a known current (I amperes) in phase with the voltage applied to the wattmeter. The field (H in gausses) at the center

TABLE I

Effective value of stray magnetic field in gausses at a distance of D cm. from the axis of symmetry of a group of long straight conductors carrying a current of 10,000 amperes and arranged as indicated in column 1, with the spacing between adjacent conductors 10 cm.

Arrangement	Formula	Stray field $D = 50$	Stray field $D = 100$	Stray field $D = 200$	Stray field $D = 500$
Single conductor, return at great distance	$\frac{0.2\ I}{D}$	40	20	10	4
Return at distance g...	$\frac{0.2\ I\ g}{D^2}$	8	2	0.5	0.08
Return in two wires on opposite sides.......	$\frac{0.2\ I\ g^2}{D^3}$	1.6	0.2	0.025	0.0006
Return in four wires at corners of square....	$\frac{0.2\ I\ g^4}{D^5}$	0.064	0.002	0.000625	.00000064
Return in coaxial cylinder...........		0	0	0	0
Three-phase circuit conductors in a plane	$\frac{2\sqrt{3}\ g\ I}{10\ D^2}$	13.8	3.5	0.87	0.138
Three-phase circuit conductors in a triangle..........	$\frac{\sqrt{3}\ g\ I}{10\ D^2}$	6.9	1.73	0.43	0.069

of such a loop is $H = \frac{2\pi N I}{10 R}$ when N is the number of turns in the loop.

III. Choice of Measuring Apparatus

The second line of procedure in avoiding stray-field errors is the proper choice of type and arrangement of measuring apparatus.

When it is feasible, use should be made of magnetically shielded instruments. In these instruments the windings are enclosed in a thick shield of high-permeability iron, which serves to greatly reduce the intensity of the stray field in the interior of the instrument. The protection thus afforded of course varies with the nature of the instrument and the design of the shield. A more detailed discussion of such magnetic shielding will be found in the papers of Curtis and Gokhale, Parts 1 and 6 of this symposium.* The literature[4,5,6] contains data showing a reduction of the stray-field error by factors which vary from ⅛ to 1/60 in different cases. As is often the case with any type of shielding there is always the danger that the presence of the iron shield may somewhat affect the action of the instrument and it is customary to laminate such shields so as to minimize the eddy currents which would otherwise be produced by the field from the instrument windings themselves. There is also a possibility of the shield acquiring a certain permanent magnetization which may affect the operation of the instrument on direct current. This effect can be eliminated, however, by taking the

*Symposium on Shielding in Electrical Measurements A. I. E. E. Summer Convention, Swampscott, Mass., June 24-28, 1929.

For all references see end of paper.

mean of readings with the currents direct and reversed.

The operating torque of many electrical instruments is the result of the interaction of two magnetic fields, one of which is much stronger than the other. This is the case, for example, in a separately-excited electrodynamometer or in a vibration galvanometer. In such types of instrument, it is desirable to so arrange matters so that the moving element of the instrument is the one which produces the weaker of the two magnetic fields. The ponderomotive force on the moving element resulting from its reaction with the stray field (which is of course fixed in space) is thereby made less than with the converse arrangement. Thus, an electrodynamic instrument should be used with the separate excitation applied to the fixed coils; and a vibration galvanometer of the fixed magnet-moving coil type should be preferred to a moving magnet instrument, unless, of course, some additional shielding is used with the latter.

Certain types of apparatus, such as electrodynamic instruments and mutual inductors, can be built in astatic form by using duplicate coils wound in opposite directions whose effects are additive as regards the currents to be measured but subtractive as regards stray field effects. Apparatus of this type is very much less subject to stray field errors than is ordinary non-astatic equipment, and should be used whenever possible. However, it is well to bear in mind that astatic construction does not entirely eliminate all possibility of stray field error. The two coils of an astatic instrument seldom have exactly the same area turns, and even if the construction is perfect, the compensation is complete only if the stray field is uniform in direction and intensity throughout the space occupied by the instrument. The field around a laboratory or power station is usually far from uniform and may be materially different at the two coils of an astatic instrument.

IV. Reversal of Connections

A further method which is almost always applicable even in cases where the circumstances have not allowed the experimenter any leeway in the arrangement of either the current-carrying conductors or the measuring apparatus is to make two sets of measurements between which the connections of part or all of the apparatus have been reversed. The most desirable procedure is first to make such changes in connections as will reverse the direction of all currents in the measuring circuits except the heavy currents which are suspected of producing a stray field. This may usually be done by reversing the secondary connections of the current transformers. If the results of the repeat measurement made after this reversal show only a slight difference from the original results, one-half this difference may be taken as a measure of the stray field error and the mean of the two results may be considered to be correct. If the difference is large, it indicates the need for locating and removing the source of error. The same principle may then be applied further by studying each piece of apparatus separately and taking a pair of readings before and after reversing its connections. In most cases it is of course necessary to reverse two pairs of terminals as for instance the primary and secondary circuits of a mutual inductor or transformer, or the fixed and moving coil circuits of an electrodynamic instrument. After a survey of this nature has shown which parts of the network are introducing the errors, these parts should be so moved or modified as to reduce the error to a reasonably small value. A final pair of readings should then be taken to give the correct mean value.

V. Connections to Current Circuit

The coupling between the measurement circuit and that carrying the large currents is usually made through a current transformer. There is unfortunately a dearth of experimental data on the effect of stray magnetic fields on the ratio and phase angle of current transformers.[7] One would expect, however, that the effect would not be greater in magnitude than the differences observed when the primary conductor is placed in different positions with respect to a hole type current transformer.[8] With most transformers, these differences amount to only a few parts in ten thousand in ratio, but with certain unfavorable combinations of construction and conditions of use, may be as great as one-half per cent.

It occasionally happens that the coupling between the measuring circuit and the heavy current circuit must be made by a direct connection of potential leads, so as to measure the impedance drop in a run of bus or across some piece of apparatus carrying the large current. In such cases it is important to recognize clearly that the impedance drop may be very different from the resistance drop and to place the potential leads so that the resultant e. m. f. at the measuring instrument may approximate as closely as possible to the desired quantity. If the total impedance drop is desired, the potential leads should be brought off separately at right angles to the heavy conductor in such a direction as to avoid so far as possible the magnetic effect of other parts of the heavy current circuit. In other words, the mutual inductance between the potential leads and the current circuit should be zero. On the other hand, if the resistance drop only is desired, a potential lead should be laid back tightly against the conductor throughout the span from its point of attachment to that of the other potential lead. From the point where the two leads meet, they should be kept close together and preferably twisted throughout the run from the conductor to the instrument. The theoretically perfect condition is to place the potential leads so that they are linked with a magnetic flux of the same amount as that which links the main conductor. In the case of round conductors this would require the impracticable condition that the lead lie in a hole or groove inside the current carrying rod. In the case of thin rectangular bars, however, the requirement can be

met by placing the potential lead close to the bar at a distance from the center of its long side equal to 0.3 of the total width of the bar.

In cases when the conductor arrangement is such that the potential leads cannot be placed in the desired location, it is often possible to correct the experimental results by computing the various mutual inductances involved. Formulas are available[9] for such computations for a great variety of shapes and arrangements of conductors.

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Abridgment of

Some Problems in Dielectric Loss Measurements

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and

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Synopsis.—The measurement of dielectric loss in high-voltage cables presents many problems which are not simple, and their solution is obtained only after considerable effort and research. This paper presents some of the problems that the authors have encountered in this type of work, together with the methods used for their solution.

The bridge method, which is used for the measurement of dielectric loss, is described in some detail. Details of the auxiliary equipment, such as galvanometer, amplifier, air condenser, shielding and special methods of bringing the shielding to the proper potential are also given.

If accurate results are to be had in dielectric-loss measurements, the entire bridge, including cable, air condenser, and leads must be properly shielded, and the capacitance between leads and shielding should be made small. It is entirely insufficient to shield the bridge and ground the shielding directly. At times, shielding cables may increase the measured losses.

In measuring the capacitance of the air condenser, all stray capacitance to its guard rings and to surroundings must be eliminated. The voltage across the voltmeter coil of a high-voltage transformer is frequently taken as a measure of the voltage across its secondary. In some methods of measurement, this voltmeter-coil circuit is an integral part of the measuring circuits. Methods of measuring the ratio of primary to secondary voltage and the phase angle between them are described, and in the complete paper considerable quantitative data are given for typical testing transformers under various conditions of load.

The accuracy of the bridge as a power-measuring device may be determined by inserting known resistances into its arms and comparing computed results with observed results. Due to unsuspected leakage and stray-capacitance currents, however, the introduction of such resistances may cause large errors. Methods of minimizing such currents are given, as are analyses of proper and improper methods of making such measurements and observed data and results. Harmonics probably do not introduce error in this type of measurement, but at times they are troublesome in that they produce anomalous effects in the measuring apparatus.

INTRODUCTION

In conducting research on ionization in impregnated paper insulated cables at Harvard University under the auspices of the Joint Committee on Paper Insulated Cables of the N. E. L. A., A. I. E. E., and A. E. I. Co., the authors have encountered many interesting problems in making the rather difficult measurements of very small amounts of power at high voltage and extremely low power factors,—a most difficult combination. We believe that as a result of this type of research, which has been stimulated by cable manufacturers and users, the technique of making these refined measurements has been advanced by many years.

In this type of measurement, many factors which in other types of measurements are not even considered introduce large errors. In order that others may be forewarned of the sources of errors encountered, and further, to give opportunity for discussion from which all will derive benefit, the authors have been requested by engineers who have been in touch with this work to publish their experiences.

There is probably no type of measurement in which one may be more easily deceived than these dielectric-loss measurements. The losses vary with temperature, with the time of electrification, the cycle of electrification, and with the handling of the specimen. Hence, accurate checks of measurements on cable samples among different laboratories cannot be expected.

Curves obtained with certain measuring apparatus may appear perfectly rational, and yet, because of phase-angle defect or wrong transformation ratio, both of which may be constant in magnitude, the curves are actually in error. As will be shown later, it is most diffi-

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cult to check a given apparatus by the introduction of known losses in the circuits. The calibrated Leyden jars, which are now available at the Electrical Testing Laboratories, have in large measure overcome some of these difficulties.

The Bridge Method

The authors use the mutual inductance bridge, which has already been described by them.[4] The complete bridge with its shielding and guard connections, as now used, is shown in Fig. 1.

The bridge proper consists of a high-voltage air condenser C_1 in series with a resistance R_1; the cable or dielectric C_2 is in series with the primary of a mutual inductance M and the resistance R_2. The detector D, which consists of a tuned iron-vane galvanometer, is connected between points a and b in series with the secondary of M. The bridge is entirely shielded by chicken wire, connected to the shielding of the air condenser. This shielding is brought to the same

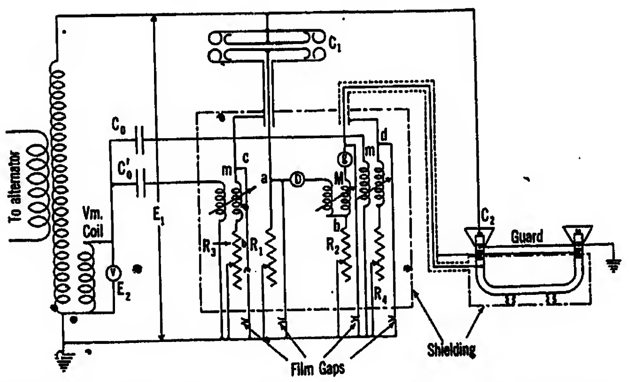

Fig. 1—Complete Connections of Bridge Circuit

potential as a by adjusting the resistance R_3, the mutual inductance m' and the capacitance c_0'. The sheaths of the cables are cut twice at each end for guards and then are completely shielded. This shielding and the inner guards are brought to the same potential as b by adjusting the resistance R_4, the mutual inductance m and the capacitance c_0.

When the bridge is in balance the power factor of the cable

$$\cos\theta = \sin\Psi = \frac{M\,\omega}{R_2} \tag{1}$$

for small values of power factor. Ψ is the angle of defect of the dielectric, M the mutual inductance in henrys, and ω is $2\,\pi$ times the frequency.

The capacitance

$$C_2 = C_1 \frac{R_1}{R_2} \tag{2}$$

The power

$$P = \frac{E^2\, C_2\, \omega^2\, M}{R_2} = \frac{E^2\, C_1\, R_1\, \omega^2\, M}{R_2^{\,2}} \tag{3}$$

4. C. L. Dawes and P. L. Hoover, *Ionization Studies in Paper Insulated Cables*. Trans. A. I. E. E., Vol. XLV (1926), p. 141.

The Detector

Without a sensitive detector the bridge loses most of its advantages as a precision instrument. The iron-vane vibration galvanometer with electromagnetic excitation has proved the most satisfactory detector. The impedance of our instrument at 60 cycles is 2200 + j 280. The degree of sensitivity is increased tremendously by the use of an amplifier. The galvanometer must be shielded from dielectric, magnetic and mechanical disturbance.

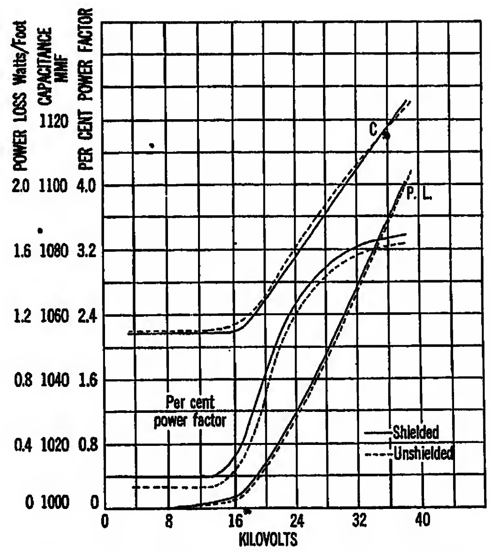

Fig. 2—Effects of Shielding 10-ft. Length Single Conductor Cable at 60 Cycles and 20 Deg. Cent

Shielding the Air Condenser, its Leads and the Bridge

It is absolutely necessary to shield the low-voltage plate of the air condenser. If the guard is grounded, it gives the condenser the equivalent of an angle of defect of some magnitude. Hence, the guard should

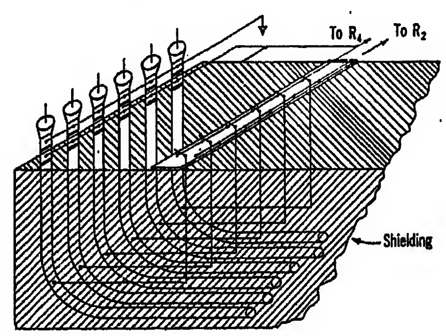

Fig. 3—Connections of Cables in Cable Rack

be brought to the same potential as the low-voltage plate. (See Fig. 1). The lead from the condenser to the bridge should likewise be shielded and should be constructed so as to have very small capacitance. This shielding and the shielding about the bridge are connected together and to the condenser guard, and brought to the potential of a, that of the low-voltage plate of the condenser.

Shielding the Cable

The cable sheath should be shielded, not only to give opportunity for eliminating capacitance to ground, but also to prevent leakage and induced charges from entering the sheath and causing errors. Also, the lead from the cable sheath to the bridge must be shielded. This shielding is all connected together and brought to the potential of point b (Fig. 1) by means of the resistance R_4, the mutual inductance m and the condenser c_0.

We have found that shielding may increase the measured loss in a cable, as shown in Fig. 2. This matter is still under investigation.

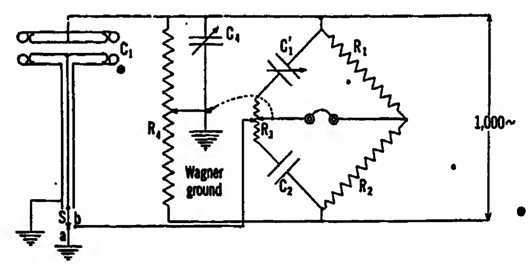

Fig. 4—Connections for Measuring the Capacitance of A Shielded Condenser

To prevent discharges to end-bells disturbing the guard-circuit balance a system of double guarding the cable ends is used. The end-bells and a short length of sheath are grounded directly (Fig. 1). A short length of lead sheath between these ends and the test length of sheath connects to the shielding as already described. Our shielding and the method of connecting six cables for test is shown in Fig. 3.

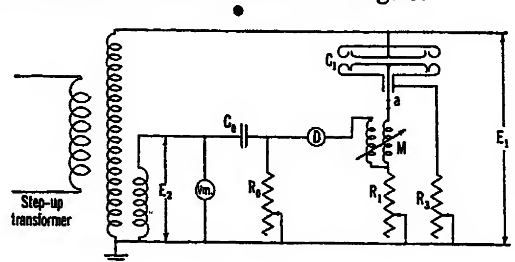

Fig. 5—Connections for Determining the Ratio and Phase Angle of Voltmeter Coil

Measurement of the Air Condenser

In measuring the capacitance of the air condenser the shielding about the low-voltage plate must always be at the same potential as the low-voltage plate but must not be included in the measurement. The measurement is made at a frequency of 1000 cycles per sec. The connections are shown in Fig. 4. With the switch S at a, the bridge is first balanced. The switch S is then thrown to b and a second balance made. The Wagner-ground balance must be made each time. The capacitance C_1 is then the difference in the settings of the condenser C_1'.

Transformer Ratio and Phase Angle

It is possible to measure the ratio and phase angle of the test transformer by using the connections shown in Fig. 5. C_1 is the high-voltage air condenser, M the mutual inductance, R_1 a resistance, D the detector, C_0 a low-voltage air condenser, and R_0 a resistance. The shielding is balanced by R_3 (also m' and c_0' may be used Fig. 1).

When the bridge is in balance

$$\frac{E_1}{E_2} = \frac{C_0 R_0}{C_1 R_1} \quad (4)$$

The angle between E_1 and E_2

$$\beta = \frac{M\,\omega}{R_1} - \omega\, C_0\, R_0 \text{ (nearly)} \quad (5)$$

(Data taken with three different test transformers without and with load are given in the complete paper.)

It is found that when the voltmeter coil is properly located, the ratio is little affected with change in voltage or load. The angle β changes considerably with load.

Checking the Bridge

It is possible to check the accuracy of the bridge in reference to both the measurement of current and the measurement of power. For example, by connecting a deflecting dynamometer at a, Fig. 5, the current

$$I_1 = E_2\, C_0\, \omega\, \frac{R_0}{R_1} \quad (6)$$

when the bridge is in balance.

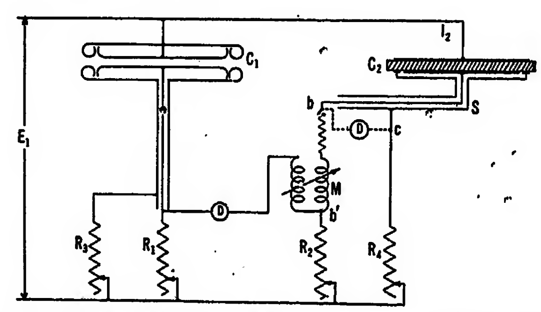

Fig. 6—Correct Method of Connecting Resistance in Series with Low-Voltage Plate

Below are representative data which we have taken

ω	E_2 kv.	R_0	C_0 μ f.	R_1	I_1 (ma.) from (6)	I_1 (ma.) (Observed)
377	25.0	1004	0.015	109	1.300	1.295

A known resistance r may be inserted in series with one of the capacitances, C_2, and the power dissipated in it calculated. (Fig. 6). If the measured power factor before the introduction of the resistance r is $\sin \Psi_1$ and the power factor after the introduction of the resistance r is $\sin \Psi_2$, then

$$\sin \Psi_2 - \sin \Psi_1 = r\, C_2\, \omega \quad (7)$$

There are many opportunities to make large errors in this measurement. For example, in Fig. 6 the guard-circuit balance must be made between points b and c and the capacitance of the resistance r to its surroundings must be very small.

With a plate-glass condenser, the measured loss without r was 7.73 watts, with r, 10.28 watts, the difference being 2.55 watts. The computed power was 2.51

watts, a close check. Also, $\sin \Psi_2 - \sin \Psi_1$ was 0.00935 as compared with the computed value of 0.00914.

With an E. T. L. standard condenser, the measured increase of power was 0.1196 watt as compared with a computed value of 0.1178 watt.

HARMONICS

Even with a sinusoidal e. m. f. wave impressed across the bridge, harmonics occur in the current wave when ionization commences. Since, with a sinusoidal e. m. f. wave, these harmonics cannot contribute power, the bridge when balanced with a tuned galvanometer ordinarily measures the power correctly. At one time when a slight third harmonic occurred in the impressed e. m. f. wave and the galvanometer was inadvertently tuned to this harmonic, the bridge balanced with a negative value of the mutual inductance. This was due to the fact that the third-harmonic voltage drop across R_1 (Fig. 1) was balanced in part by the third-harmonic drop in R_2 due to ionization in the cable and the phase relation of the third-harmonic voltage drop across one of these resistances has no particular relation to the third-harmonic voltage drop across the other.

The authors are indebted to P. H. Humphries of the Harvard Engineering School and to L. E. Cirella of the Simplex Wire & Cable Company for their assistance in obtaining data given in this paper; and to Prof. H. E. Clifford of the Harvard Engineering School and D. W. Roper, F. M. Farmer, and W. F. Davidson of the Joint Committee for their suggestions in its preparation.

Abridgment of

Shielding and Guarding Electrical Apparatus Used in Measurements—General Principles*

BY HARVEY L. CURTIS†

Fellow, A. I. E. E.

Synopsis.—Electrical measuring apparatus is shielded and guarded to protect it from the following external influences; namely, leakage currents, electrostatic fields, magnetic fields, and electromagnetic waves. Apparatus is guarded against leakage currents which may flow over or through the solid insulators on which the apparatus is supported. It is shielded against leakage currents which flow through the fluid in which the instrument is immersed. By a proper arrangement of guards and shields any apparatus can be completely protected against leakage currents.

Any apparatus can be completely shielded from electrostatic fields by placing it in a metallic case. However, there may be electrostatic reactions between the apparatus and the shield, thus introducing errors in the measuring apparatus.

Shielding apparatus from magnetic fields requires that the apparatus be surrounded by a thick enclosure of magnetic material. The theory of this magnetic shielding has been developed and formulas for producing the most satisfactory shielding are given.

The shielding of an apparatus from electromagnetic waves is largely accomplished by means of eddy currents which these waves set up in the shield. The theory for the production of these eddy currents has been developed and the best location of shields is discussed.

Some attention is given to the errors which may be introduced by shielding and some methods are outlined for obviating the necessity of shielding.

* * * * *

I. INTRODUCTION

GUARDS and shields are used with electrical measuring apparatus either to simplify its theory or to protect it from external influences. The simplification of theory has generally resulted from a rearrangement of the electric or magnetic field so that the resulting field can be more easily subjected to mathematical analysis. The external influences from which apparatus must be protected are: (1) Leakage currents, (2) magnetic fields, (3) electrostatic fields, (4) electromagnetic waves.

It is the purpose of this paper to discuss the general principles underlying the guarding and shielding of electrical apparatus.

The protection of apparatus from external influences has sometimes been called guarding the apparatus and sometimes shielding it. The following definitions seem to represent the best practise: A shield protects apparatus from those outside influences which may penetrate to the instrument through the medium by which it is surrounded. A device for the protection of apparatus from leakage currents which, for the most part, flow over the surfaces of the solid insulators used to support the apparatus is called a guard. The term "guard" is also applied to those devices the purpose of which is to rearrange the electric or magnetic field. For example, the earthed plates which are sometimes put under the insulating supports of an electrometer to prevent leakage currents are called guard plates, while if the electrometer is surrounded by a metal covering to protect it from the ionization currents of

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the air, this covering is a shield. Also, if a parallel plate condenser has one plate surrounded by a ring to diminish edge effects, this ring is a guard ring. However, if the back of the guarded plate is surrounded by a housing to prevent any electrostatic lines from reaching the back of the plate, this housing is a shield. While these usages of the terms "shield" and "guard" might, to advantage, be modified, they will be adhered to throughout the paper.

II. Guarding and Shielding Apparatus Against Leakage Currents

Guarding apparatus against leakage currents is necessary whenever the solids used in the insulation of the apparatus have so low a volume resistance or surface resistance as to allow a leakage current to flow which will influence the measuring apparatus. Shielding apparatus against leakage currents is necessary whenever the fluid (air, oil, etc.) in which the apparatus is immersed permits a measurable current to flow. In ordinary measurements, guarding against leakage is required more often than shielding.

The leakage currents against which apparatus must be guarded may flow through the material of which the solid insulators are made or through a film of moisture or dirt on the surface of the insulators. With some insulating materials (amber, ceresin, hard-rubber, paraffin, silica-glass, sulphur, etc.), the leakage current through the material of the insulator is, in well designed apparatus, negligibly small. Surface leakage on the other hand is often troublesome, especially since it may be quite variable. The method of guarding, however, is the same for both volume and surface leakage.

To guard an apparatus as completely as possible every insulator is made in two parts. One part of each insulator supports a piece of metal (the guard) on which is mounted the second part that in turn supports the measuring apparatus. An auxiliary electric circuit, similar to the one in the measuring apparatus, is then set up and so connected to the guards that the potential of each guard is substantially the same as that of the conductor in the measuring apparatus which it supports. Hence there is no tendency for a leakage current to flow through or over the second part of the insulator which is between the measuring apparatus and the guard.

Shielding air-immersed apparatus against leakage currents is necessary only when the apparatus is sensitive to exceedingly small currents or when the number of ions is unusually large. No general statement can be made as to the sensitivity of apparatus that requires shielding. It is customary and usually necessary to shield the essential portions of a circuit when an electrometer[3] in employed as the measuring instrument. It is usually unnecessary to shield when using a galvanometer unless the instrument is exceedingly sensitive or the surrounding air highly ionized.

1, 2. For references see Bibliography.

*Here the current which flows over the surface of the insulation is, by means of the guards, shunted around the measuring instrument.

III. Guarding Apparatus to Simplify Its Theory

In some types of measurements, it is desirable to determine the constants of the apparatus from the known properties of the surrounding medium. In such cases a guard may be employed either to confine the field of the measuring apparatus to that portion of space where the properties are known, or to modify the field so that the constants of the apparatus can be computed from its dimensions. In many cases one guard may perform both of these functions. A well known example is a guard-ring air condenser. Here the guard ring is useful not only to confine the lines of force to the air so that the dielectric loss is negligible, but also to make the field between the plates uniform so that the capacitance can be readily computed.

While guards are often useful, they should be used with care lest they introduce errors which are greater than those they are supposed to rectify. The possibility of errors is well illustrated by the guard-ring condenser. When it is used as a standard having zero power factor in a-c. measurements, the assumption is tacitly made that the potential of the guard ring is at *every instant* the same as the potential of the guarded plate. This requires not only that the two alternating potentials shall have the same magnitude and be in the same phase, but also that they shall have the same wave form. Hence, not only must the impedance of the guard circuit be properly adjusted, but also it must be protected from corona and other effects which would change its wave form. Again, when the guard ring is used to simplify the computation of the capacitance, the edge correction is not zero unless the gap between the guard and plate is infinitely narrow. Hence, a correction[4] must, for precise work, be applied to the computed capacitance to allow for the finite width of the gap.

IV. Shielding of a Space from Electrostatic Fields

A given space can be perfectly shielded from external electrostatic fields by surrounding the space with a continuous metallic enclosure which is maintained at a definite potential, usually at earth potential. Provided this could always be used, nothing further would have to be written concerning electrostatic shields. The shield however, may react unfavorably on the apparatus that is being shielded. In such cases it may be necessary or advisable to omit the shield entirely, or to use less effective methods of shielding.

The most troublesome reaction between apparatus and shield is caused by capacitance. The placing of a grounded shield close to a piece of apparatus will very markedly increase not only the capacitance to earth but also the capacitance between parts of the shielded apparatus. As an example consider a shielded resis-

tance coil. Often such a shield is used to make definite the capacitance between the different parts of the coil, particularly that between the terminals. However, if the shield is placed very close to the terminals, slight changes in the position of the shield (such as those produced by changes in temperature) may cause changes in the capacitance between the terminals greater than the changes which would have occurred had no shield been present. This difficulty can readily be overcome by making the shield larger.

V. Shielding of a Space from Magnetic Fields

A given space can be shielded from a constant magnetic field only by surrounding the space by magnetic materials. Perfect shielding is not possible but good results can be obtained by the use of suitable materials provided they are in the most efficient shapes.

The shielding of spaces against the earth's magnetic field is probably the oldest problem in magnetic shielding. It early became of importance in the design and use of needle type galvanometers. Here the shielding might not be important if the earth's field were perfectly constant. However, the changes are of such long period that the effect of these changes can be made negligible only by reducing the entire field to a very small part of its original value.

The early attempts at magnetic shielding consisted in enclosing the space in a single shell of iron.[6] Later it was shown that two or more shells could be used to advantage. This problem was first treated theoretically by Rücker[7] for two and for three spherical shells. Later DuBois[8] gave a more complete treatment for two spheres and for two cylinders. Wills[9] extended this to cover three spheres and three cylinders. More recently Esmarch[11] and Dye[14] have given the general expression for the shielding produced by any number of cylinders provided their successive radii form a geometric progression.*

All of these derivations have assumed that the external field is uniform and of such a small value that the permeability of the shields can be considered constant. Also the shields are assumed to be concentric and the axes of the cylindrical shields are assumed to be perpendicular to the lines of magnetic force. The cylindrical shields are assumed to be sufficiently long so that end effects can be neglected. In practise this means that the length should be twice the diameter.

The important results of the theoretical investigations can be stated as follows:

1. The shielding ratio (defined as the ratio of the external to the internal magnetic field) is approximately proportional to the permeability of the material of which the shields are constructed.[8]

2. The thickness of the shields should not be great. For example, a single spherical shield, the thickness of which is greater than $\sqrt{2 r_1^2/\mu}$, (r_1 = internal radius of shield and μ is permeability), will be improved by removing a spherical lamina, and thus reducing the total amount of shielding material.[7]

3. For both spheres[7] and cylinders[9] the best thickness and spacing is that in which the radii of the successive bounding surfaces of the shells are in geometric progression. From this it follows that any increase in the volume of the space to be shielded requires the same relative increase in the volume of the shields.

Within a few years some experimental work has been done to determine the shielding effect of spirals made from high permeability material. In some cases the shield was made by winding in a tight spiral a single sheet of magnetic material. In other cases, a sheet of magnetic material and a sheet of non-magnetic material (copper or paper) were placed together and wound into a spiral so that in the resulting shield the magnetic material was interleaved with non-magnetic material. Characteristic results are given in Table I. These results show the value of inter-leaving, though the exact thickness of the inter-leaving does not seem to be important.[15] The increased shielding that can be obtained by the use of the high permeability alloys of nickel and iron is well illustrated by the values of Hill[16] for mumetal.

VI. Shielding a Space from Electromagnetic Waves

The problem of shielding a space from electromagnetic waves depends on the frequency of these waves. When the frequency is very low, the electric and magnetic fields change so slowly that the shielding problems are nearly identical with those for stationary fields. When the frequency is very high, shielding becomes a problem in the optical opacity of materials. For intermediate frequencies, consideration must be given not only to the instantaneous values of the electromagnetic and electrostatic fields, but also to the rate at which these fields are changing.

Since in any particular case the waves emanate from a single electric circuit, the electric and magnetic vectors at a given place have a definite direction. In the nomenclature of optics, the waves are polarized. The three vectors which determine (1) the direction of motion of the wave, (2) the direction of the electric field, and (3) the direction of the magnetic field are mutually perpendicular. Hence, they may be taken as

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*Assume there are n shields of permeability μ, the successive radii (starting from the smallest) are $r_1, r_2, \ldots \, r_{2n}$. The odd subscripts give the inside radii and the even subscripts the outside radii. The shielding ratio, g, ($= H_e/H_i$ where H_e is the external field and H_i is the field inside the shield) is given by the formula

$$g = K_n r_1^2/r_{2n}^2 \text{ where}$$
$$K_n = \{2\beta + [\beta - 1]^2 \mu/4\} K_{n-1} - \beta^2 K_{n-2}$$

in which

$$\beta = \frac{r_2^2}{r_1^2} = \frac{r_3^2}{r_2^2} \ldots\ldots = \left(\frac{r_{2n}^2}{r_1^2}\right)^{\frac{1}{2n-1}}$$

Since K_n depends on K_{n-1} and K_{n-2}, the values for K_1 and K_2 are not given by this formula. They are

$$K_1 = 1 + (\beta - 1)\mu/4$$
$$K_2 = \{2\beta + [\beta - 1]^2 \mu/4\} K_1 - \beta$$

Dye[14] gives curves to aid in computing the shielding ratio.

TABLE I
SHIELDING RATIO OF DIFFERENT MATERIALS

Reference	Kind of magnetic material	Thickness—cm. Magnetic material	Thickness—cm. Interleaves	Weight kilos	Inner diam. cm.	Outer diam. cm.	Shielding ratio 3 H_e/H_i
13	Transformer steel	0.26	0.14		4.	8.	180
		0.26	0.		4.	8.	50
	Cast iron	4.	..		4.	8.	20
15	Mumetal	0.15	0.25	0.5	10.	12.	10,000

the axes of a rectangular coordinate system. The effect of a shield will depend on its orientation relative to this coordinate system.

The eddy currents which are set up in the shield may be produced either by the electric field of the wave or by the magnetic field, or by both.[17] The method by which waves produce eddy currents can be made clear by considering some particular cases. In the complete paper, two cases are considered; *viz.*, a system of parallel wires, and a laminated cube.

In order to compute the shielding which will be produced by any arrangement of solid metallic bodies, it is necessary first to compute the eddy currents that will be produced in the metal. The formula for determining the current density in a particular case is generally determined by the solution of Maxwell's differential equations of an electromagnetic field. It results that the eddy currents in a massive conductor are always a function $\sqrt{\frac{f\mu}{\sigma}}$, where f is the frequency of the wave, μ the permeability of the material, and σ its resistivity. This shows that the most effective shielding materials are those having high permeability and low resistivity.

Formulas for computing the eddy currents produced by electric waves have been derived in certain cases.[16] However, in relatively few cases have the theoretical deduction been carried to a point where the shielding power can be computed. Some experimental work[18] has shown that there is a qualitative agreement between theory and experiment.

VII. Limitations of Shielding

In a previous section, the effect on any measuring apparatus of an electrostatic shield in which it is enclosed was discussed. In any given case, the reaction between the shielded apparatus and an electrostatic shield can be expressed in terms of the coefficients of capacitance. Likewise a magnetic shield or a shield which protects against electromagnetic waves reacts with the apparatus which it is shielding. However, in neither of the latter cases can the amount of reaction be expressed by a simple formula.

It has already been pointed out that an electrostatic shield may introduce errors in a measuring apparatus for which it is difficult to make a correction. With a magnetic shield, on the other hand, the effect of the reactions is to change the sensitivity of the apparatus. As the apparatus is calibrated with the shield in place no error results from the use of the shield. However, the reactions are so complicated, involving eddy currents, hysteresis, permeability, etc., that each separate type must be subjected to an experimental investigation.

In absolute electrical measurements, where the constants of an apparatus are computed from the mechanical dimensions, shields must generally be avoided. As an example, the inductance of a coil can often be accurately computed from its dimensions. However, the formula for making the computation is developed on the assumption that the permeability of the surrounding space is unity; that is, that there are no magnetic bodies in the surrounding region. Evidently a magnetic shield would vitiate this fundamental assumption. Moreover, the derivation of the formula takes no account of the capacitance between the parts of the inductance. While this generally produces a negligible effect, yet the presence of an electrostatic shield will so increase the capacitance between parts that an appreciable effect is produced. Hence, an electrostatic shield must be avoided.

VIII. Methods for Obviating the Necessity of Shielding

Astatic instruments are often used for obviating the necessity of shielding. In an astatic piece of apparatus two similar parts are constructed. In the finished apparatus these parts are rigidly connected mechanically, but the electric and magnetic circuits are so arranged that an external electric or magnetic field will produce equal and opposite effects in the two parts. When the apparatus is placed in an electric or magnetic field which is uniform throughout the region which the apparatus occupies, then changes in the magnitude of this field will not affect the indications of the instrument. This method has been applied to galvanometers and inductors.

IX. Conclusion

In conclusion it may be said that the general principles underlying the shielding and guarding of electrical apparatus are well known, but that their quantitative application by means of mathematical analysis is often difficult or at present impossible. Hence, shields and guards should be used with care. Whenever possible the shielded or guarded apparatus should be subjected to special experiments to show that the effect on the apparatus is not determental.

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Railway Train Signal Practise

BY P. M. GAULT[1]

Non-member

Synopsis.—This is a description of an automatic block signal system used on single track. Signals are located over or to right of track governed. Cab signals are a development of recent years. Indications must be easy to read. Three colors are used—red, yellow, and green. Signals are dependent upon track circuits for proper control and operation. Energy for operation is supplied by storage batteries trickle charged from commercial sources of alternating current. Current for lamps is taken directly from a-c. lines with automatic cut over to storage batteries in case of failure of supply line. Lens unit of light signal is a doublet combination with a special lens for use on curves. Absolute permissive block system provides head-on protection from station to station and permits following movements with clear signals with intermediate blocks between stations. Tonnage markers permit heavy trains to pass red signals on grades where, if stopped, these trains could not be started.

Signal circuits are designed on the closed circuit principle. An organization for construction and maintenance of a Signal Department is outlined.

The systems of signals installed along railroads for the protection of train movements is the general subject covered in this paper. Though the information given here applies particularly to signals used on the Missouri Pacific Lines, the principles and general applications hold true regardless of the individual railroad.

An automatic block system may be defined as a series of consecutive blocks governed by block signals operated by electric, pneumatic, or other agency actuated by a train, or by certain conditions affecting the use of a block.

A block is a length of track of defined limits, the use of which by trains is governed by block signals.

Automatic block signals may be divided into four general types:

1. Semaphore signals which give their day indication by the position of a semaphore arm, in the right-hand upper or lower quadrant for steam roads and usually in the left-hand upper quadrant for electric lines. The night indication is given by colors.

2. Color light signals which give the indication by the color of a light, day or night.

3. Position light signals which give the indication by the position of a row of lights day or night. Aspects of position light signals have the same position as the day aspects of semaphore signals.

4. Color position light signals which give their indications by a combination of color and position of lights.

Signals are located preferably over or to the right of the track which they govern. In recent years there have been several installations of cab signals placed in operation. These signals may be of any of the above four types, in miniature, and are located on the engineman's side of the cab where they will, at all times, be within his range of vision. If desired the signals may be duplicated and one placed on the fireman's side of cab as an extra precaution.

A cab signal, like a wayside signal, to be of any value as protection against the accidents which automatic signals are designed to prevent, must at all times be directly responsive to conditions ahead of a train which may affect its movement. The particular advantage of a cab signal is that it goes right along with the loco-

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motive and gives immediate warning in case of a dangerous condition ahead.

The cab signal has been developed in connection with the continuous systems of automatic train control, which have been installed within the past five years as a result of certain orders of the Interstate Commerce Commission. To describe this development fully would require more time than we have available so I will confine my remarks to the automatic block system using wayside signals.

The indications given by automatic signals are comparatively easy to read,—in fact, this is a fundamental requirement for the reason that the engineman of a high-speed train must know immediately, exactly what information it has to impart so that he can act at once to properly control his train.

In all of our new installations on the Missouri Pacific Lines we are using the color light type of signal. Three colors are provided which, unless otherwise modified, are:

Red —*Stop*
Yellow—*Proceed at Restricted Speed*
Green —*Proceed*

These are the indications to the engineman and tell him what he is to do. Stated in another way, the red light indicates that the block immediately ahead is not clear, either it is occupied by a train, a switch is open, a car is not in the clear on a turnout, a rail is broken, or there is some other condition existing which requires restriction of movement. A yellow light indicates that the first block ahead is clear, but the next signal is red so that the engineman must have his train under control and be prepared to stop before the next signal is reached. A green light indicates that the next two blocks ahead are clear; the way may be clear for a greater distance but this is a minimum. In locating signals it is always best where conditions will permit, to space them not less than braking distance apart for the train which requires the greatest distance to stop. If it is not practicable to do this, it is necessary that control of signals be arranged so that trains will receive a so-called caution indication at a point which is braking distance or greater from the stop signal.

Various means of controlling signaling devices had been tried out in the early days of the art. Some made use of time elements which were actuated by a train as it passed; others provided a trip device, which counted a train into a block and then counted it out at the other end. All of these schemes were open to serious objections, for if a train stopped in a block, or left cars in a block, or if a wire was broken, a following train would receive a clear signal.

Beginning about 1867, William Robinson entered actively into the development of a signal system. After realizing the serious objections to the various schemes proposed, he developed a closed rail track circuit substantially as it is today, and in 1871, applied for a patent to cover; this patent was issued August 20, 1872 and reissued July 7, 1874.

All automatic block signals depend for their proper functioning upon a track circuit. It is the most important part of the system; upon it we depend to coordinate the signal system with the moving train.

The Signal Section, A. R. A., defines a track circuit as "an electrical circuit of which the rails of the track form a part."

Most steam roads use the direct current track circuit although alternating current is used on a goodly mileage and must be used on electric lines where d-c. propulsion is used.

The essential parts of a track circuit are a source of electrical energy, rails, bonding, relay, and insulated joint.

For d-c. track circuits, various types and arrangements of batteries are used to supply energy. A few years ago gravity batteries were largely used for this purpose; then followed the caustic soda cell, which has been and continues to be very popular. Of recent years the storage battery, trickle-charged, has been used in many installations.

The rails of a track circuit provide an easy path for the flow of current from the battery, but it is necessary to provide some sort of bond around the angle bars which are used to splice the rails together. Various types of bonds are used, ranging from two No. 8 B. W. G. EBB. galvanized wires, fastened to the rail with channel pins, to a short copper stranded bond which is welded to the rail.

The relays used with d-c. track circuits must operate on comparatively weak currents which flow through the rails. Various resistances have been used but the Signal Section of the American Railway Association recommends that relays be 2 or 4 ohms.

The operating characteristics of a standard new track relay of four ohms resistance are pick-up maximum 0.078 amperes, working current maximum 0.120 amperes, drop-away minimum 0.037 amperes. This is a relay having four front contacts and two back contacts.

The condition of the ties and ballast have considerable bearing on the operation of the track circuit. Where cinder ballast is used and it is not clear of rails the resistance between the rails, ballast resistance, may run as low as two ohms per thousand feet of track in wet weather; with rock ballast in good condition, dry weather ballast resistance may run as high as 100 ohms per thousand feet of track.

With either storage battery or caustic soda battery, it is necessary to use a fixed resistance in series with the battery to limit the flow of current to rails when the track is short circuited either by a train or unfavorable ballast conditions. This is not necessary with gravity batteries on account of their high internal resistance.

The author has gone somewhat into detail in describing the track circuit for the reason that it is absolutely necessary to understand its operation to get the full benefit of the description of the signal system.

Referring to our description of the track circuit, we see the following possibilities. A broken wire, a broken rail, a broken battery jar, a shunted track, or a misplaced switch (each switch is provided with a circuit controller which shunts the track when switch is open unless otherwise provided) will cause the track relay to become deenergized and its contacts to open. Signals may be controlled through as many track circuits as desired and thus the signal will correctly tell us the condition of the track for a predetermined distance ahead.

Relays which repeat the track relays and which are energized over line wires are used where it is necessary to repeat more than one track relay or where a signal is to be controlled through some distant function.

The new signals which we are using on the Missouri Pacific Line are, as stated before, of the color light type. Each unit is provided with a 10-volt, 18-watt lamp. These lamps are burned at slightly less than nine volts in order to get long life. Where local conditions will permit, we light them automatically on the approach of a train; normally they are dark.

Any signal of this type to give a good indication must be properly lined with respect to an approaching train; it must also be so constructed that all units will give their maximum indication at the same point. Provision must be made to renew lamps without disturbing the focusing of the signal. We are using a rebased lamp in our signals. This is a lamp which has the bayonet collar soldered on in such a way that the pins are always in exactly the same location with respect to the filament; each socket being carefully located with respect to the lens unit, lamps may be replaced without interfering with the focusing of the unit.

A brief description of the lens unit, Fig. 1, of the signal we have used in our latest installations may be of interest. It consists of a doublet lens unit with a fixed light source, the lamp filament. The inner lens of the doublet combination is of high transmission colored optical glass, which determines the color of the signal indication. This inner lens is of very short focal length and therefore intercepts a maximum quantity of the light rays from the filament of the lamp, which is located at its focal point. These rays are bent by refraction so that they are directed upon the outer lens at angles coincident with its focal point and they emerge from the outer lens in practically parallel rays, forming a cylindrical beam of colored light. Where a modification of the beam is necessary to meet condition found on a curve, a roundel or cover glass is used to spread or deflect the light beam. The structure of the entire unit is such that the axial center of the light and the lenses and the focal length of the lenses are accurately positioned and permanently held in their proper fixed relation to one another. Lenses employed have a total spread of three to four degrees, but when necessary this spread can be increased to 20 or 30 degrees by the use of deflecting roundel mentioned above. This is done at the cost of loss in beam intensity; however, long range signals are rarely required on curves so that this is not objectionable.

On our single track we are using a scheme of automatic signaling which has been termed the "absolute permissive block system," Fig. 2. The name refers to the manner of controlling the signals and has nothing whatever to do with the construction of the signals. It may be described as a system of signaling, which provides absolute or positive blocking for opposing train movements between fixed locations, usually passing tracks, but which will permit following train movements between these same two locations. It may best be described by an example.

Assume two passing tracks T and R, five miles apart. A pair of signals will be located at each end of each passing track and the five-mile section between passing tracks may be divided into four blocks, which will require three pairs of intermediate signals. The leaving signal at each passing track will have some special designating mark; we use a large letter A, which is backed with reflecting glass. When this signal is red, trains may not pass it after stopping unless authorized to do so by the dispatcher or when preceded by a flagman. This is the *absolute* signal. All of the others are permissive signals, that is, a train finding one of them red must, unless otherwise provided, stop, after which it may proceed at slow speed expecting to find a train in the block, a broken rail, or some condition affecting the movement of the train. A train leaving T will set all opposing signals between T and R red so that it is protected against any opposing trains. Firstly the absolute signal at R is red and this is a "stop" signal, but further protection is given for the case where both trains happen to pass the *absolute* signals at the same instant, because all other opposing signals will stop the opposing train. This protection results when the train sets all opposing signals between T and R red. As the train proceeds through the territory from T to R, it is protected in the rear by one red and one yellow signal so that following or permissive moves may be made.

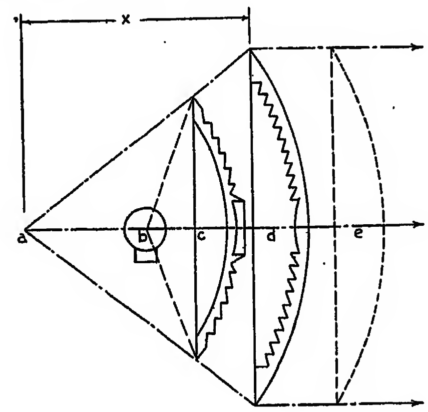

Fig. 1—Doublet Lens Unit

There are locations at which, if a heavy train is

stopped, it will be unable to proceed without doubling or without a considerable loss of time and fuel and with possible damage to equipment. When necessary to install a permissive signal at one of these places, we provide on the pole below and to the right of the light unit, a special designating marker consisting of a letter *T*, which is constructed similar to the *A* described above. Any train with over 75 per cent of the tonnage rating of the locomotive, may pass a signal equipped with this tonnage marker when the red light is burning, but must

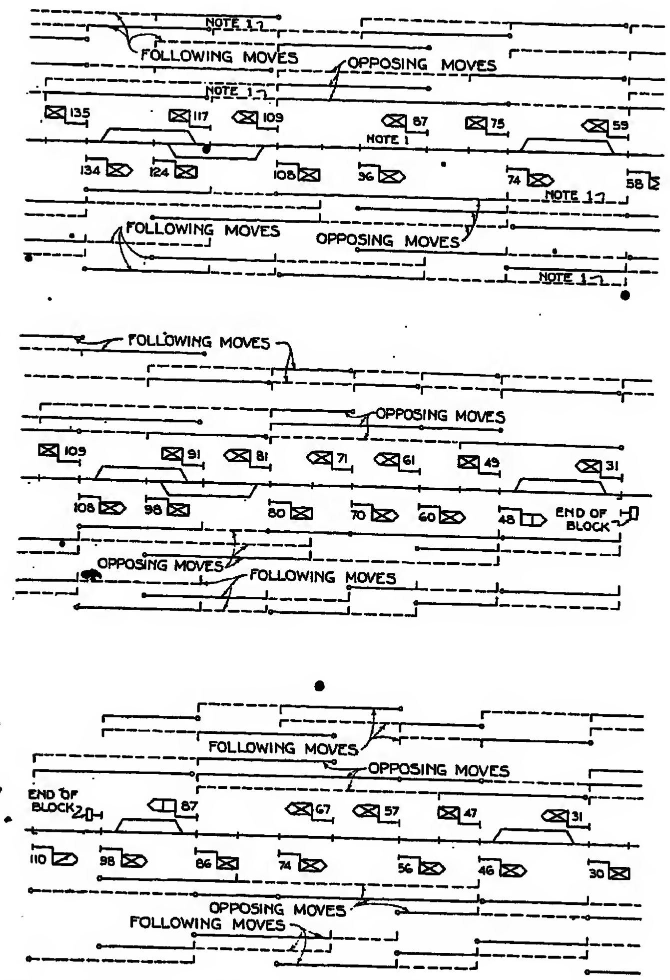

Fig. 2—Typical Overlap Diagram—Absolute Permissive Block System

Note 1. When distance 87 to 96 is less than 2640 ft., distance controls shall extend one track section in rear of opposing absolute signal as shown.

Note 2. Full and dash lines marked "following moves" and "opposing moves" show the control limits of each signal. Full lines indicate the track section which, if occupied by a train, will cause the signal to give a stop indication; as extended by dash lines the same signal will give an approach or caution indication with a train in the section covered by the dash line extension.

Each signal is numbered for identification.

proceed at slow speed prepared to stop short of another train or an obstruction.

There is another type of single-track automatic signaling known as the "overlap system." In this scheme a train moves in a protected zone which extends both ahead and behind a sufficient distance, so that it includes both a red and a yellow signal. This system of signaling is perfectly safe and is used on a large mileage; it is claimed, however, that it will limit track capacity more than the absolute permissive system.

One of the rules of the operating department of a railroad is that a signal imperfectly displayed or the absence of a signal at a place where a signal is usually shown, must be regarded as the most restrictive indication that can be given by that signal.

In so far as practicable, every signal and every signal circuit is designed on this same principle; that is, the failure or removal of any part will result in a more restrictive indication. Every detail must be watched to see that all of the devices will operate under widely varying conditions of service such as temperature and humidity variations, size, weight, and speed of trains, etc.

A very careful record is kept of the failures of the apparatus to function as intended. Inasmuch as every failure may mean a train delay, it is vital that these reports be watched carefully, each failure studied and corrective measures applied as quickly as possible. It is to the credit of the designers of the apparatus and the maintenance forces of the railroads that signal performance records are very high. It is not unusual to have 100,000 operations per failure on a division and averages for an entire system frequently run this high.

As you no doubt realize, it requires a considerable organization to look after the installation and maintenance of the signal system of a large railroad. This work is handled by a sub-department of the engineering department on most railroads. A signal engineer heads the organization and he and his staff are responsible for the design, construction, and maintenance of all signals, interlocking plants, and highway crossing protection. The field work is handled by men reporting to division supervisors of signals. Each maintainer and his assistant are given from 20 to 40 miles of signals to maintain, depending upon the amount of other apparatus, such as interlocking and highway crossing protection, which is located in the territory.

According to the report of the Interstate Commerce Commission, there were as of January 1, 1928, 53,616 miles of automatic block signals in service in the United States. At that time there were 199,154 miles of railroad over which passenger trains were being operated. This excludes lines which operate only one locomotive. During the five year period ending January 1, 1928, automatic block signal mileage increased 12,089 miles.

We now have more than 1700 miles of the Missouri Pacific on which automatic signals are either in service or under construction.

This paper merely touches on some of the more important features of an automatic block system. Interlocking plants, highway crossing protection, and automatic train control devices, all of which are closely related to the automatic signal system, form a large part of the work of the signalman. Each of these subjects would be worthy of a separate description.

Abridgment of

Electrical Wave Analyzers for Power and Telephone Systems

BY R. G. McCURDY[1] and P. W. BLYE[1]

Member, A. I. E. E. Member, A. I. E. E.

Synopsis.—This paper describes two types of electrical analyzers which have been developed for the direct measurement of harmonic components of voltage and current on power and telephone systems. These devices are assembled mechanically in a form suitable for use in either the laboratory or in the field. Both instruments, which differ chiefly with respect to sensitivity and input circuit arrangement, employ multistage vacuum tube amplifiers and two duplicate interstage selective circuits.

The power circuit analyzer is designed to measure harmonic voltages in the frequency range from 75 to 3000 cycles, and over a voltage range from 0.5 millivolt to 50 volts. The telephone circuit analyzer operates over the same frequency range and measures harmonic currents as low as 0.05 microampere and voltages as small as 0.005 millivolt. Both analyzers are adapted to measure small harmonic voltages and currents in the presence of the fundamental component and other harmonics relatively large in magnitude.

A number of devices are described which have been adopted for eliminating various sources of error. The paper presents in detail the characteristics of both instruments with respect to selectivity, sensitivity, linearity, balance of input with respect to ground, generation of harmonics and susceptiveness to stray fields.

* * * * *

Introduction

The solution of many problems in electrical engineering, involving currents and voltages of complicated wave-shapes, can be carried out most practicably by a study of the individual sinusoidal components into which these complicated waves may be resolved. This is particularly true in the case of problems dealing with the inductive coordination of power and telephone systems, since the induced noise in telephone circuits occurs largely at frequencies corresponding to the harmonic components in the current and voltage waves of neighboring power systems.

In recent years, many of the development and research problems in inductive coordination, with which the Bell System has been concerned, have required an accurate and comparatively rapid field method of analyzing complex waves. The analyzers which are described in this paper have been developed to meet the particular requirements of these studies. The development of these instruments has proceeded in close association with the progress of the field work and modifications were made in the designs from time to time as necessitated by the requirements of the work. This has resulted in the production of two types of analyzers one of which is particularly adapted for use with suitable instrument transformers and shunts on power circuits, and the other for use on telephone circuits. For convenience, these have been termed the power circuit analyzer and the telephone circuit analyzer.

These analyzers have been in active service in the field for some time and have permitted the obtaining of many valuable data as to coefficients of induction between power and telephone systems, the wave shape of power machinery and systems, and analyses of noise currents on telephone circuits. They are arranged in suitable form for use in either the laboratory or in the field and in some instances have been mounted in specially equipped testing trucks.

Aside from their use in this work on inductive coordination, it is felt that the instruments may have a field in other power and communication problems in which a knowledge of the magnitudes of harmonic voltages and currents is important or where measurements at single frequencies are desired in the presence of extraneous voltages and currents as large or larger than the single frequency it is desired to investigate.

The over-all accuracy of an instrument of this type depends upon the conditions surrounding its use. These include the magnitude of the component being measured as compared to the magnitudes of the fundamental and other harmonics present, the relative magnitudes of the voltage across the terminals of the instrument and the voltage between these terminals and ground, and the severity of stray fields from nearby power circuits. Under average conditions, the analyzers which are described in this paper should give results with an over-all accuracy of within ± 5 per cent of the quantities measured. By means of these instruments it is possible to make a complete analysis of a complex wave over the frequency range up to 3000 cycles in from 30 to 45 min., depending upon the number of harmonic components present. The working up of the results in terms of volts and amperes consists in multiplying together not more than three quantities. The obtaining of a complete harmonic analysis in terms of volts or amperes should not, therefore, require more than one man-hour. The apparatus is so arranged that practically simultaneous analyses may be made of a number of currents or voltages.

General

As stated above, two general types of analyzers, have been developed, the first being designed for use on

1. Am. Tel. & Tel. Co., New York, N. Y.

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power systems, while the second, a more sensitive instrument, is intended primarily for measuring currents and voltages of the magnitudes commonly experienced on telephone systems.

The requirements of both types of analyzers, with respect to selectivity and at the same time insensibility to commercial frequency variations, are practically the same. Therefore, the same selective equipment, designed to give a response curve which is parabolic in form, has been employed in both instruments. Other

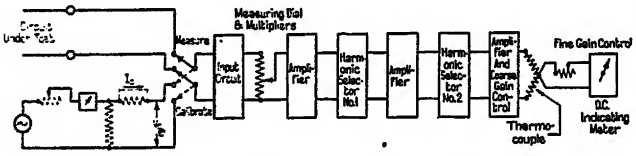

Fig. 1—Schematic Diagram of Analyzer Circuit

requirements which have been particularly considered in the development of the analyzers have to do with sensitivity, impedance of input circuits to be provided, insensibility to stray fields and the limiting of harmonics generated within the instruments due to modulation effects. In both analyzers and in the telephone analyzer in particular, special consideration has been given to the matter of input circuit balance with respect to ground. This is in order that the accuracy of measurement may not be impaired when the voltage across the input circuit is small as compared to the voltage between the input terminals and ground, a condition which frequently obtains on telephone systems. The methods employed in meeting these various requirements and their effectiveness will be discussed in detail below.

Electrical Circuit. Each analyzer consists essentially of a multistage vacuum tube amplifier equipped with suitable controls, a measuring dial and associated multipliers, a calibrating circuit and a sensitive d-c. indicating meter operated by a thermocouple in the output circuit of the amplifier. Selectivity is afforded by means of duplicate tuned circuits inserted between stages of the amplifier. A schematic diagram indicating the general arrangement of the analyzer circuit is shown in Fig. 1.

The particular circuit features of the power and telephone analyzers will be discussed in the following sections of the paper.

Mechanical Arrangement. For convenience in transporting and setting up the apparatus in the field, each type of analyzer has been assembled in two units, known as the "amplifier unit" and the "harmonic selector Unit" respectively. The selector units used with both the telephone and power circuit amplifiers are identical. A completely assembled power analyzer, together with its calibrating oscillator, is shown in Fig. 3, in which the lower unit is the harmonic selector and includes all the equipment making up the selective circuits, the upper is the amplifier unit and includes the measuring circuits, the vacuum tube amplifier and its incidental control apparatus.

Harmonic Selector. These analyzers employ as a selective device two independent tuned circuits operating in tandem. The effect of the two circuits in tandem is to discriminate against extraneous harmonic components close to the tuned frequency in proportion to the square of the differences between their frequencies and that to which the circuits are tuned. The response curve obtained with such an arrangement is therefore approximately parabolic in form, being relatively flat in the immediate neighborhood of the tuned frequency and falling off extremely rapidly at frequencies substantially different from that at which the circuits are in resonance.

On account of the errors which would result from small frequency variations, the maximum selectivity available with two tuned circuits of this type cannot generally be used practicably on commercial systems. The *A* curves in Fig. 4 indicate the over-all degree of selectivity obtained with the analyzer with padding resistances in series with the two resonant circuits to degrade the selectivity somewhat, this being the arrangement commonly used. The *B* curves indicate the selectivity with these resistances short-circuited.

A schematic circuit diagram of a single section of the harmonic selector unit is shown in Fig. 6. As is indicated in this figure each section consists essentially of a series resonant circuit consisting of a fixed inductance and an adjustable capacity. This resonant circuit is coupled to the plate-filament circuit of the preceding amplifying tube by a condenser of relatively low impedance (4.5 μ f.) which is common to both

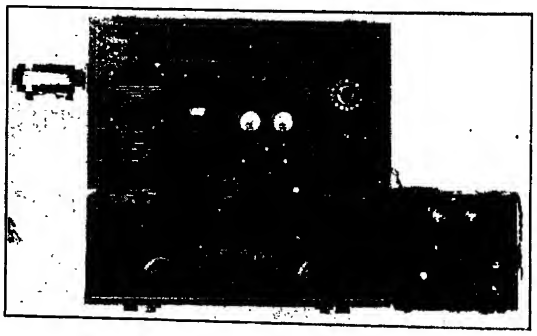

Fig. 3—Power Circuit Analyzer and Calibrating Oscillator

circuits. The voltage across the inductance branch is utilized as the output of the tuned circuit and is impressed across the grid-filament circuit of the following amplifying tube. This arrangement together with an equalizing network gives an amplification-tuned frequency characteristic which is relatively flat.

In the amplifier unit designed for use with the harmonic selector on power systems, three input circuits are provided for measuring power circuit voltages, currents, and small voltage across shunts, respectively.

The impedances of these three circuits and the sensitivities available are as follows:

Quantity measured	Input impedance	Minimum measurable current or voltage
Voltage.........	10,000 ohms	0.05 volt
Current.........	0.2 ohm	2.5 milliamperes
Millivolts.......	1,000 ohms (Approx.)	0.5 millivolt

At fundamental frequencies the minimum measurable voltages and currents are ten times those given above.

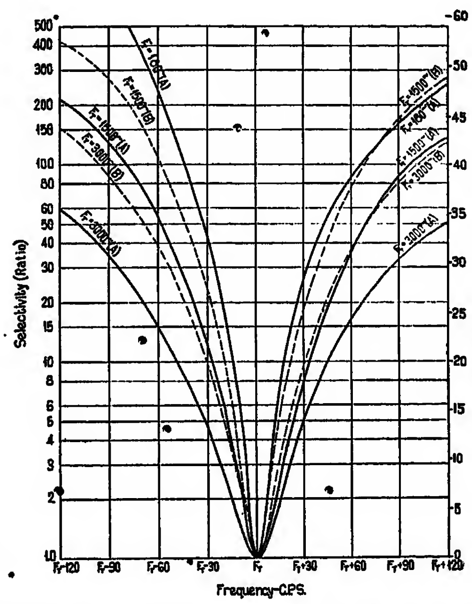

Fig. 4—Selectivity of Two Sections of Harmonic Selector in Tandem

$$\text{Selectivity} = \frac{\text{Response at Tuned Frequency } (F)}{\text{Response at Extraneous Frequency } (T)}$$

A schematic diagram indicating the general arrangement of the input circuits in the power amplifier is given in Fig. 8. These circuits are designed to measure harmonic components over a range of from 1 to 1000

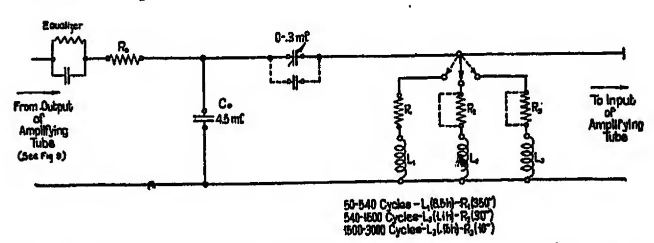

Fig. 6—Single Section of Harmonic Selector—Schematic

times the current and voltage values given in the above table. Errors due to non-linearity in the input circuits over this range do not exceed approximately ± 3 per cent at frequencies from 120 to 3000 cycles.

In order to avoid errors due to the effects of relatively large voltages to ground on the input terminals the input circuits are shielded and accurately balanced with respect to ground. As an example, the degree of balance attained in the input circuits of one particular instrument is indicated in the following table:

Frequency ~per sec.	Apparent voltage across measuring circuit per volt above ground	
	Current and millivolts circuit	Voltage circuit
180	0.000007	0.0007
540	0.000008	0.0008
1020	0.000013	0.0014
2100	0.000021	0.0022
3000	0.000024	0.0027

In order to avoid the generation of harmonics of appreciable magnitudes within the analyzer itself due to modulation effects, it was found necessary to provide special devices for suppressing the fundamental component of the wave under analysis and for balancing out harmonics generated in the input transformers.

These means for controlling the generation of

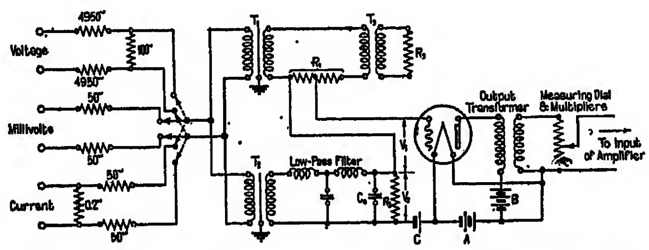

Fig. 8—Power Analyzer—Input Circuit—Schematic

harmonics have proved very effective. In one particular instrument the generated harmonics observed in the case of a 60-cycle fundamental voltage of 102 volts were as follows:

Fundamental voltage	Per cent generated harmonics						
	2nd	3rd	4th	5th	6th	7th	9th
102 volts.......	0.07	0.08	0.008	0.02	*	*	

*Too small to measure—less than 0.01 per cent.

The power amplifier unit is specially shielded against stray electrostatic fields at all susceptible points with copper shielding. Similar shields of annealed iron are provided with all susceptible wound apparatus as a protection against stray electromagnetic fields. A large number of tests carried on in the field indicate that the analyzer is sufficiently well shielded for general use in the vicinity of power apparatus.

A circuit diagram of the amplifier which is used in conjunction with the input circuits described above is shown in Fig. 9. This portion of the circuit is identical in both the power-circuit amplifier and the telephone-circuit amplifier which is to be described below.

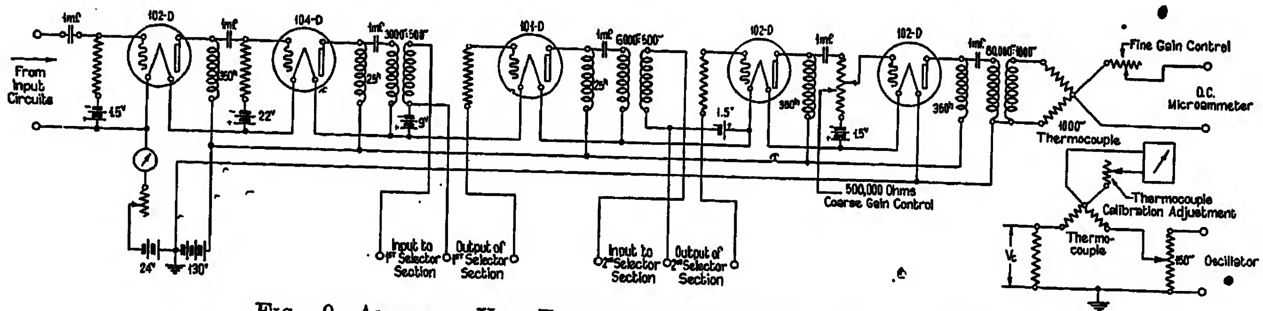

FIG. 9—AMPLIFIER UNIT EXCLUDING INPUT CIRCUITS—CIRCUIT DIAGRAM

TELEPHONE CIRCUIT AMPLIFIER

The amplifier which has been designed for use with the harmonic selector on telephone systems differs from the power-circuit amplifier chiefly in the matter of sensitivity and in the arrangement of its input circuits. A schematic diagram of the input circuit of the tele-

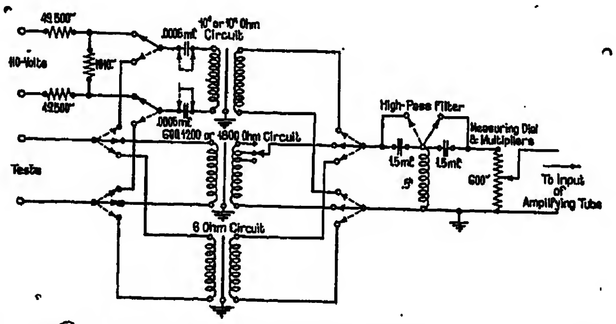

FIG. 10—TELEPHONE ANALYZER—INPUT CIRCUIT—SCHEMATIC

phone circuit amplifier is shown in Fig. 10. As is indicated in this diagram the input circuit is provided with three individual transformers by means of which the following circuit arrangements and sensitivities are obtained:

Quantity measured	Input impedance	Minimum measurable current or voltage
Voltages...........	6 ohms	0.005 millivolt
Voltages...........	600 ohms	0.05 millivolt
Voltages...........	120,000 ohms	0.5 millivolt
Voltages...........	1,000,000 ohms (600 cycles)*	5.
Power Voltages.....	100,000 ohms	0.05 volt
Currents...........	600 ohms	0.05 microampere
Currents...........	1,200 ohms	0.035 microampere
Currents...........	1,800 ohms	0.03 microampere
Currents...........	6 ohms	0.5 microampere

*This circuit consists of 0.00025 μ f. in series with the 120,000 ohms of the transformer and measuring dial. Its impedance and sensitivity, therefore, vary with frequency.

The minimum measurable currents and voltages at fundamental frequencies are ten times those tabulated above.

The input circuits of the telephone-circuit amplifier have been found to operate satisfactorily over a range of currents and voltages from 1 to 2000 times those tabulated above.

The balance of the input circuits with respect to ground is an important feature in the case of the telephone-circuit amplifier in view of the large ratios between voltage to ground and metallic-circuit voltage which usually exist on telephone lines.

The degree of balance attained in the input circuits by careful shielding and the use of special transformers is indicated in the following table:

Input circuit	Frequency	Apparent voltage across circuit per volt to ground
Current (6-ohm)........	3000	0.0000015
Current (6-ohm)........	540	0.00000035
Current (600-ohm).....	3000	0.000012
Current (600-ohm)......	540	0.000002
Voltage (120,000-ohm)..	3000	0.00029
Voltage (120,000-ohm)..	540	0.00002
Voltage (0.00025 μ f.)....	3000	0.0046
Voltage (0.00025 μ f.)....	540	0.0042
Power voltages.........	3000	0.025
Power voltages.........	540	0.001

As is indicated in the circuit diagram of Fig. 10 a high-pass filter consisting of a series condenser of 1.5 microfarads and a shunt inductance of 0.5 henry is included in the input circuit. This filter is effective on systems having a fundamental frequency of 60 cycles or less, in suppressing the fundamental component of the complex wave under analysis. The generation of harmonics in the analyzer due to modulation effects is, therefore, practically confined to the input transformers.

The generated harmonics in one particular telephone-circuit amplifier unit, expressed in per cent of the fundamental component are as follows:

Circuit	Fundamental component	Per cent generated harmonic 2nd	3rd	5th	7th
Current (600-ohm).......	0.001 ampere	0.28	0.27	0.049	0.006
Current (6-ohm).........	0.01 ampere	0.25	0.25	0.05	0.009
Voltage (120,000-ohm) volts.................	10	0.25	0.25	0.05	0.007

While the telephone circuit amplifier is not ordinarily exposed to stray fields of large magnitudes, the instrument has been shielded at susceptible points in much the same manner as the power analyzer. Tests in the laboratory and in the field indicate that except under unusually severe conditions the shielding is sufficient to permit the use of the analyzer in the vicinity of power apparatus.

Abridgment of

Quick-Response Generator Voltage Regulator

Field Tests Made With Oscillograph

BY E. J. BURNHAM[1], Associate, A. I. E. E.
J. R. NORTH[2], Member, A. I. E. E.
and I. R. DOHR[3] Non-member

Synopsis.—This paper describes elaborate and severe field tests made on high-speed excitation equipment used with a 5385-kv-a. turbo generator. Complete oscillograms and curves showing the performance of this equipment are included, together with a discussion of the results obtained.

* * * * *

DURING 1928, high-speed excitation equipment was provided for a 5385-kv-a. house turbo generator, which is used for supplying power to essential auxiliaries at the Saginaw River Steam Plant of the Consumers Power Company. Elaborate field tests were made on this regulating equipment, constituting the most severe tests made on a machine of such size, and the results are indicative of those which may be obtained on the larger size generators.

Description of Installation

The No. 1 house turbo generator on which these tests were made is a General Electric unit rated 5385 kv-a., 3500 kw., 0.65 power factor, 2500 volts, 3600 rev. per min., 60 cycles and has a direct connected exciter rated 33.5 kw., 250 volts, four-pole, shunt wound.

The house turbo generators supply power to the more essential station auxiliaries consisting of boiler feed pumps, draft fans, circulating pumps, condensate pumps, etc. All motors used with these auxiliaries are started on full voltage and the larger ones of 400-hp. capacity are of the squirrel-cage type. The house generators may be operated in parallel with or isolated from the rest of the system.

A General Electric Type FA-1 high-speed generator voltage regulator is provided to control the excitation of the No. 1 house generator. This regulator is equipped with a three-phase torque motor control and rheostatic follow-up features.

Requirements

This high-speed excitation equipment was installed to accomplish the following:

a. To accurately control the a-c. voltage under all conditions of picking up and dropping load without disturbing the operation of the other station auxiliaries operated from the same machine.

b. To obtain a high speed of excitation response in connection with this generating unit in order that even the largest induction motors (400 hp.) used for station power service could be satisfactorily started at full voltage with minimum disturbance.

c. To obtain first hand information concerning the operation of this type of quick response regulator, particularly regarding its speed of operation, precision, and stability of operation.

Design of Regulating Equipment

In order to meet the above requirements, a quick-response excitation system was provided consisting of

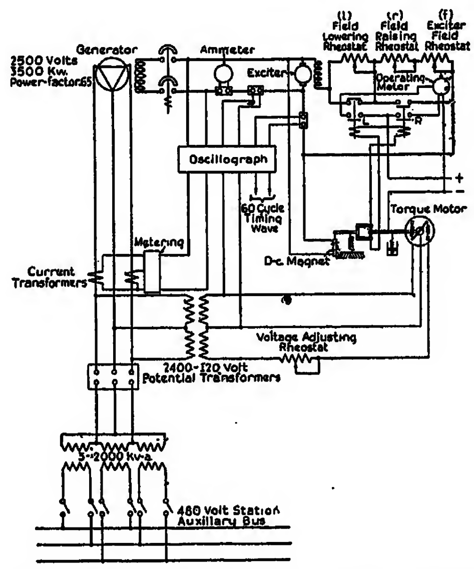

Fig. 1—Diagram of Regulator and Test Connections Saginaw River Steam Plant

an exciter with a high speed of voltage build-up and a high-speed regulator. The exciter is self-excited and has a speed of voltage build-up of approximately 1000 volts per second over the operating range.

Fig. 1 shows a simplified diagram of connections of the house generator excitation system and the FA-1 regulator. Figs. 2 and 3 show illustrations of this regulating equipment. The main control element consists of a d-c. system and an a-c. system and includes two lever arms, one controlled by a three-phase torque motor and the other by a d-c. magnet. A contact on the a-c. lever arm floats between two contacts on the d-c. lever arm. The torque motor is energized from two potential trans-

1. General Electric Co., Schenectady, New York.
2. Stevens and Wood, Incorporated, Jackson, Michigan.
3. Consumers Power Company, Jackson, Michigan.

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formers which are connected to the three phases of the alternator, thus giving three-phase control. The d-c. magnet is connected across the armature of the exciter and provides the necessary anti-hunting feature and also the vibrating of main contacts.

Quick response in the regulator is obtained by use of a spring dashpot connected to the a-c. lever arm of the main control element. The springs in the dashpot allow either main contact to close without waiting for the movement of the diaphram in the oil dashpot.

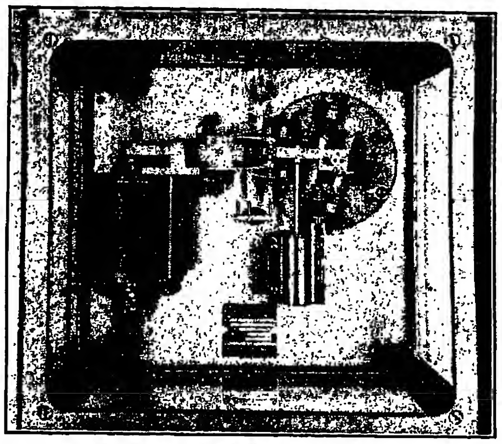


Fig. 2—Front View of Regulator Main Control Element

This dashpot tends to stabilize the operation of the main contacts. This spring dashpot can also be applied to the vibrating type of regulator to obtain quick response.

The anti-hunting feature is provided by means of the d-c. coil on the main control element. This d-c. element opens either the upper or lower main contact, after such contact is once made by the torque motor.

Operation of Regulating Equipment

With the a-c. voltage of the alternator normal, the main control element is in equilibrium, and the regulating equipment remains at rest. A decrease in a-c. voltage causes the torque motor to close the upper main contact, thus energizing contactor *R*, which in turn short-circuits rheostats *r* and *f* causing an increase in excitation. Upon an increase in a-c. voltage, the lower main contact closes, thus energizing contactor *L* which inserts rheostat *l* in the exciter field circuit to decrease the excitation.

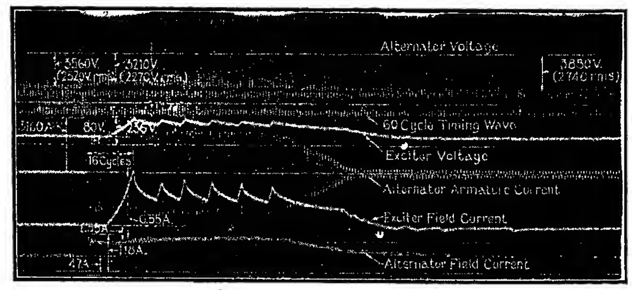
For a decrease in a-c. voltage, the upper main contact and contactor *R* will open and close, thus functioning as a vibrating type regulator until the a-c. voltage returns to normal and the main element is in equilibrium. In the same manner, an increase in a-c. voltage will cause vibration of the lower main contact and contactor *L* until the a-c. voltage returns to normal.

Each time that either high-speed contactor, *L* or *R*, is operated, an auxiliary contact energizes the motor of the motor-operated rheostat in the correct direction to bring the a-c. voltage back to normal, and the equipment back to equilibrium.

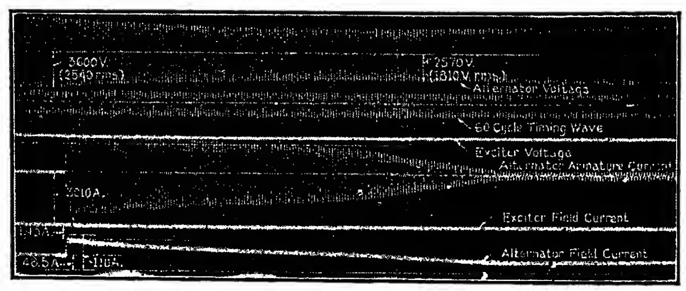
Field Tests on Regulating Equipment

An extensive series of field tests was conducted on this regulating equipment to enable it to be adjusted under actual service conditions and to obtain detail information regarding its operation. These tests consisted of suddenly picking up or dropping large amounts of load with the excitation of the generator under regulator control, and also with fixed excitation. Complete oscillographic records were obtained as well as graphic voltmeter charts and readings on indicating meters. The operation of the regulating equipment when the generator was paralleled with the rest of the system was also recorded.

Load was suddenly applied by starting one or two 400-hp. motors simultaneously at full voltage. Starting two motors simultaneously was equivalent to a momentary load of approximately 7500 kv-a. or approximately 130 per cent generator rating at approximately 35 per cent power factor lagging. The motors came up to speed in a very short time, approximately one second with the regulator in service and two seconds with fixed excitation, and their load demand dropped rapidly to a low value as soon as they came up to speed. Load was suddenly dropped by operating the generator paralleled with the system and carrying load, then suddenly opening the generator oil circuit breaker.



Test No. 7
Generator isolated and carrying no-load
Regulator in service
Started No. 3 and No. 6, 400-hp. motors



Test No. 8
Generator isolated and carrying no-load
Regulator not in service
Started No. 3 and No. 6, 400-hp. motors

Fig. 4—Oscillograms of Tests Nos. 7 and 8

Discussion of Results

From the curves, Figs. 8 to 11 inclusive, the results obtained with and without the regulator can be compared for the different test conditions.

As previously pointed out, the starting of two 400-hp. motors at full voltage constituted a load of approximately 7500 kv-a. at approximately 35 per cent power factor lagging. The inrush current to the motors upon starting is practically all wattless; therefore the duty upon the generator is severe as far as maintaining a-c. voltage is concerned because of the highly demagnetizing action of the armature current. The maximum momentary value of inrush current was the same with fixed excitation as with the regulator in service and was approximately 145 per cent of the generator current rating when starting two motors. It was approximately 100 per cent of the generator current rating when starting only one motor. With fixed excitation this current continually decreased in value after the first instant. However, with the regulator in service it was maintained near its maximum value until the motors approached full speed.

Fig. 8 shows the results with and without the regulator in service under the condition of starting two motors at a time when the generator was carrying no load.

The effect of the generator carrying load when starting two motors can be seen by comparing Figs. 8 and 9.

Fig. 11 shows the effectiveness of the voltage regulator in limiting the rise of generator voltage upon the dropping of load.

Table II gives a summary of the test results and shows the successive operating intervals of the different portions of the excitation system from the instant the generator load changes until the generator voltage is restored to normal, the speed of voltage build-up of the exciter and the generator, and the limits of exciter and generator voltages reached during the tests.

The successive operating time intervals represent the time in cycles required for the individual portions of the excitation equipment to operate. It will be noted that the main contacts of the regulator closed in approximately 2.5 cycles after the load changed. The auxiliary raised contactors closed in approximately

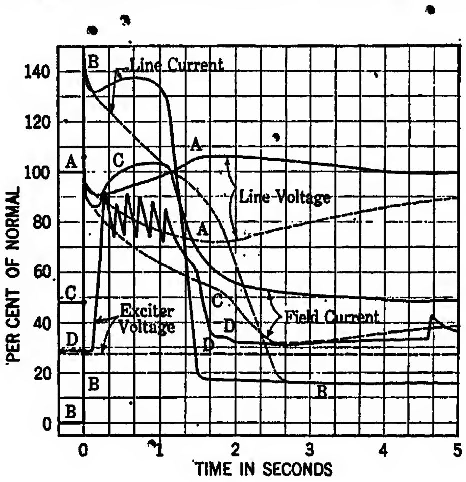


Fig. 8

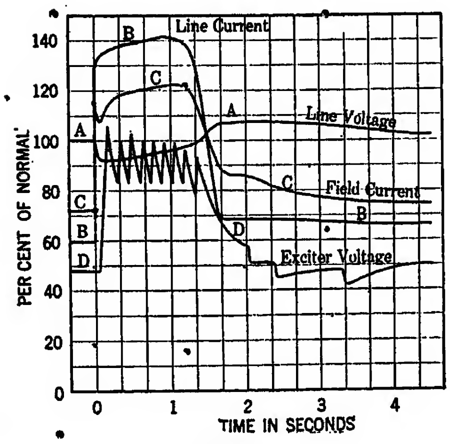


Fig. 9

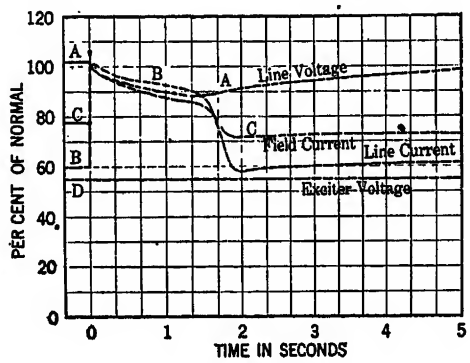


Fig. 10

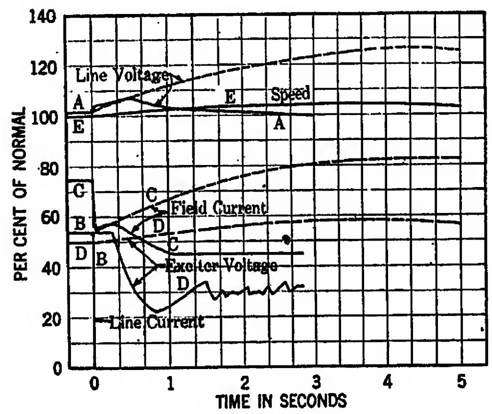


Fig. 11

Figs. 8, 9, 10 and 11.—Curves Showing Results of Tests Nos. 7 and 8, 9, 10, and 11 and 12 Respectively

A. Line voltage 2500 volt = 100 per cent.
B. Line current 1245 amperes = 100 per cent.
C. Field current 110 amperes = 100 per cent.
D. Exciter voltage 250 volts = 100 per cent.

Fig. 8 with generator isolated and carrying no-load started two 400-hp. motors.—Regulator in service; . . . . Fixed excitation. Fig. 9 with generator isolated and carrying load started two 400-hp. motors; regulator in service. Fig. 10 with generator isolated and carrying load started two 400-hp. motors; regulator not in service. Fig. 11 generator paralleled with system and carrying load; dropped load.—Regulator in service: . . . . Fixed excitation.

TABLE II
SUMMARY OF TEST RESULTS

Test conditions			Successive operating time intervals (cycles)					Speed of build-up (Volts per sec.)		Generator voltage		
						Total‡						
Excitation	Generator	Load	Main contacts	Aux. contactors	Exciter voltage	(A)	(B)	Exciter	Gen.†	Normal	Min.	Max.
Regulated	Isolated No load	Picked up	2.0	3.0	9	65	660	930	300	2540	2240	2620
Fixed	Isolated No load	Picked up	....	....	....	1200	1200	....	−290*	2530	1870	2530
Regulated	Isolated No load	Picked up	2.0	3.0	11	70	720	1040	270	2520	2270	2740
Fixed	Isolated No load	Picked up	....	....	....	1200	1200	....	−500*	2540	1800	2540
Regulated	Isolated Carrying load	Picked up	2.0	2.0	7	83	600	1200	225	2540	2250	2660
Fixed	Isolated Carrying load	Picked up	....	....	....	720	720	....	−170*	2630	2210	2630
Fixed	Paralleled Carrying load	Dropped	....	....	....	....	....	....	225	2660	....	3240
Regulated	Paralleled Carrying load	Dropped	3.0	14	37	110	720	−140*	−110*	2540	....	2720
Regulated	Isolated No load	Picked up	2.5	8.0	....	....	....	....	150	2540	2390	2600

Note: *Indicates rate of voltage decay.
†Approximate rate during time motors coming up to speed.
‡A Time interval refers to point when generator voltage first returned to normal.
‡B Time interval refers to point when generator voltage became stable at normal value.

four cycles after the main contacts closed and the exciter voltage built up to its maximum value in an average time of approximately nine cycles after the auxiliary contactors had closed. The corresponding operating time intervals with the regulating equipment decreasing the excitation are somewhat longer. As shown by Test No. 12, the auxiliary lowering contactor closed in 14 cycles, and the exciter voltage decreased to its minimum value in 37 cycles after the auxiliary contactors had closed.

The above time intervals are of interest as regards the operation of the various component parts of the regulating equipment, but from an operating standpoint, the total time interval elapsing from the instant the load changes until the generator voltage is restored to normal is of prime importance. Referring again to Table II, it will be seen that with the regulator in service the generator voltage first returns to the normal value in an average time of approximately 81 cycles or about 1.5 seconds. As previously mentioned, the generator voltage overshot and finally became stable at the normal value after a total average time interval of 570 cycles or 9.5 seconds. With fixed excitation, the voltage returned to normal after an average time interval of approximately 20 seconds. It was rather hard to determine at just what point the generator voltage became stable at the normal value, but the above values are relative.

Conclusions

The following conclusions may be drawn from the results of these tests:

a. The quick response excitation equipment is effective in reducing the magnitude and duration of a-c. voltage surges due to sudden increase or decrease in load.

b. From an operating standpoint, the over-all speed of a-c. generator voltage response is of prime importance rather than exciter speed of build-up. In other words, the total time interval from the instant of load change to the time when the a-c. voltage is restored to normal is most important.

It is estimated that the railroads of America, as the result of systematic safety contests among employes during the past five years, have saved the lives of 1383 employes, and have prevented over 180,000 additional serious accidents to employes.

These estimates are based on official Interstate Commerce Commission statistics, comparing the 1923 accident rates of these railroads with the lessened accident totals which have been achieved as the direct result of systematic and competitive safety contests among employes.

In recognition of this splendid safety work among these railroads for the year 1928, the National Safety Council last month presented a number of awards to the winners of the Railway Employes' National Safety contest. The awards were presented by Major Henry A. Reninger, president of the National Safety Council.

Interconnection in the Southwest

BY GEO. A. MILLS[1]
Member, A. I. E. E.

Synopsis.—Interconnected electric service in the Southwest has kept pace with the country as a whole. Eight states are now connected by a continuous transmission system, operated at a voltage of 60,000 volts or more. This system extends 720 mi. from East to West and 810 mi. from North to South. A description of the system is given in this paper.

A few years ago the supply of electrical energy in the Southwest centered around the larger communities, obtaining such supply from steam plants located within the boundaries of the city. The nearby communities were served by moderate voltage transmission lines radiating from these plants.

In the arid sections of the district where condensing water is scarce, oil engines were used extensively as a basis of power generation and for load development.

In the past few years development has progressed with the expansion of existing power plants and the extension of transmission networks around the larger urban areas. In the northern section of the district this development has practically covered a majority of the territory; however, in the southern portion there still exist many scattered small plants and low voltage transmission systems.

The great industrial development which started a few years ago and is now under way, has brought about a change. The small plants and low voltage networks were not only unable to furnish the capacity needed but were unable to serve economically the large industries demanding a power supply. This brought about a consolidation of the smaller properties into larger operating groups, the constructing of higher voltage transmission lines, and the development of larger base load plants.

Such development, in providing an ample supply of economical energy, has stimulated general expansion in all lines of activity such as agriculture, by providing an energy supply for irrigation pumping, gins, oil mills, creameries, condenseries, cheese factories, and general service to the farm; refrigeration; mining, smelting, and quarrying; saw mills, paper mills, and other wood product industries; the oil industries, in the electrification of drilling and well pumping equipment, refineries, pipe line pumping stations and compressor stations; and last but not least, has improved the standards of city life in industrial, commercial, and domestic activities.

The general territorial growth has been so rapid that at the present time the larger operating groups have covered the intervening territory so the border transmission lines have been interconnected, thus bringing about the present interconnected network. These interconnections have been a natural procedure since the operating executives and transmission engineers have in most cases selected similar distribution voltages from sixty to seventy thousand volts with the idea of interconnection in the future. This selection was made necessary on account of the great distances between load centers and the scarcity of favorable plant locations near the load centers, requiring a high distribution voltage to take care of the situation properly.

The skeleton transmission map, Fig. 1, shows the present interconnected lines operated at 60,000 volts and higher voltage. The map also shows the location

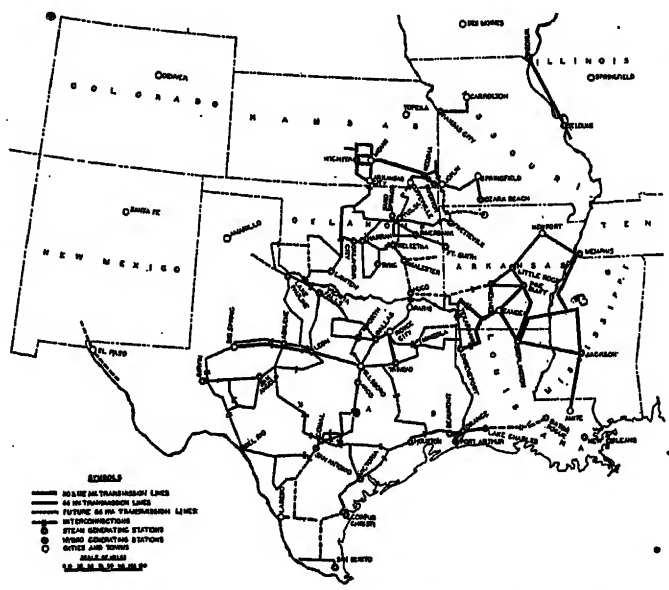


FIG. 1—INTERCONNECTED TRANSMISSION SYSTEM OF THE SOUTHWEST

of points of interconnection between various operating groups and the major power stations.

The great distances between power supply points is evident by an inspection of the map. It is to be noted that the distance of continuous interconnected line stretching from Memphis, Tennessee, to the Ozark hydro plant in Missouri, is 1500 miles. The interconnected territory from east to west is 720 miles wide and from north to south is 810 miles in extent.

INTERCONNECTION CONTRACTS

The first interconnections made in the Southwest were the result of smaller operating companies purchasing energy from the larger companies having excess prime capacity. The contracts covering these interconnections and the rates used therein were based entirely on the purchase of prime energy. During the

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past two years several new interconnections have been made under contracts wherein it has been desirable to utilize the excess capacity of a company which has installed a large power unit ahead of its own customers' requirements. These contracts provide for the mutual benefits of interconnection in meeting operating emergencies and provide for emergency operation of standby plants to hold total plant investment to a minimum cost.

Executives and engineers are fast recognizing the desirability of such mutual contracts since they provide a method of keeping the reserve capacity to a minimum and allow the installation of larger, more economical prime movers, resulting in greater economies and better service to the customer than if the developments were made independently.

Power Supply

Table I lists the principal operating plants in the Southwest connected to one interconnected network. It is to be noted that of 1,415,475 kilovolt-ampere capacity, only 22,500 kilovolt-ampere is hydro.

TABLE I
PRINCIPAL OPERATING POWER PLANTS

Name or location	Capacity in kv-a.	Prime movers
Ozark Beach, Mo.	11,250	Hydro
Riverton, Kan.	72,000	Steam turbine
Neosha, Kan.	50,000	Steam turbine
Wichita, Kan.	37,500	Steam turbine
Harrah, Okla.	81,250	Steam turbine
River Bank, Okla.	28,125	Steam turbine
Byng, Okla.	21,900	Steam turbine
Oklahoma City, Okla.	12,500	Steam turbine
Bell Island, Okla.	17,250	Steam turbine
Sand Springs, Okla.	14,700	Steam turbine
West Tulsa, Okla.	37,500	Steam turbine
Weleetka, Okla.	18,750	Steam turbine
McAlester, Okla.	10,600	Steam turbine
Lawton, Okla.	11,250	Steam turbine
Lake Pauline, Tex.	18,750	Steam turbine
Abilene, Tex.	6,250	Steam turbine
San Angelo, Tex.	12,500	Steam turbine
Girvin, Tex.	22,500	Steam turbine
Wichita Falls, Tex.	13,500	Steam turbine
Leon, Tex.	38,000	Steam turbine
Ft. Worth, Tex.	55,000	Steam turbine
Dallas, Tex.	103,000	Steam turbine
Trinidad, Tex.	50,000	Steam turbine
Waco, Tex.	15,000	Steam turbine
Shreveport, La.	37,500	Steam turbine
Texarkana, Ark.	9,375	Steam turbine
Sterlington, La.	101,850	Steam turbine
Little Rock, Ark.	16,500	Steam turbine
Pine Bluff, Ark.	13,375	Steam turbine
Remmel, Ark.	11,250	Hydro
Memphis, Tenn.	67,500	Steam turbine
Jackson, Miss.	6,875	Steam turbine
Comal, Tex.	75,000	Steam turbine
San Antonio, Tex.	36,125	Steam turbine
Victoria, Tex.	11,250	Steam turbine
San Benito, Tex.	26,250	Steam turbine
Deep Water, (Houston) Tex.	125,000	Steam turbine
Gable Street, Houston, Tex.	35,000	Steam turbine
Neches Plant, Beaumont, Tex.	64,750	Steam turbine
Port Arthur, Tex.	9,800	Steam turbine
Sabine River, Orange, Tex.	9,000	Steam turbine
Total	1,415,475	

The largest and most recently constructed plants in this territory have been laid out with the idea of utilizing the interconnected lines in disposing of the excess energy. In several cases single unit plants were operated, using the interconnected lines to other plants as reserve capacity until the load reached a point justifying a second unit. At the present time four such plants shown in the lists are operating on this basis.

The future power supply will be from the expansion of present base load steam plants located where condensing water is ample and fuel economical, and from future hydro plants in west Texas, northwest Arkansas, southern Missouri, eastern Oklahoma, and south Texas. All of these developments are made possible on account of interconnections since the projects offer capacities in excess of local requirements.

The proposed hydro developments are of unusual

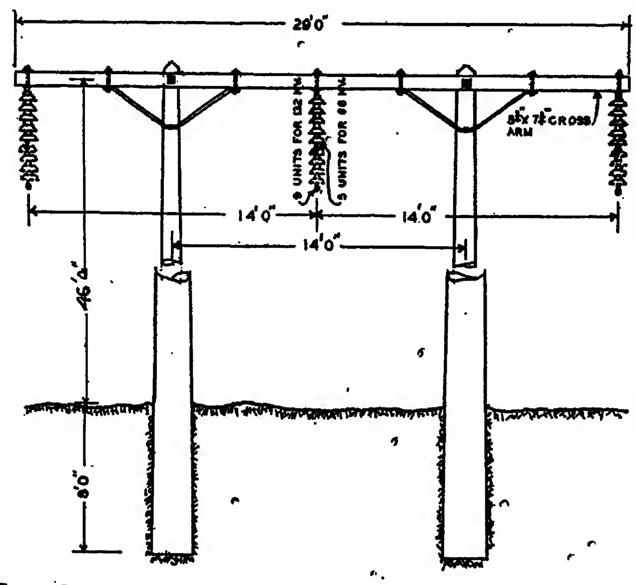

Fig. 2—Typical Structure Used in the Southwest for 66-Kv. and 132-Kv. Transmission Lines

interest since the lakes created will be utilized for flood control and in south Texas the water impounded will be of untold value in providing water for irrigation downstream from the dams. The largest sites are in the Texas Big Bend country of the Rio Grande, miles away from any industrial development.

Line Construction

The present tendency in interconnecting line construction is the use of not less than No. 4/0 conductor supported on H-frame creosoted Southern pine pole structures, spaced for 132,000-volt operation, located on private right-of-way following the shortest path between power supply and load centers or interconnecting points. A typical pole structure is shown on Fig. 2.

Steel towers in the Southwest are only used for special crossings, multiple circuits away from plants and substations, through congested urban areas, and in one or two cases, for double circuit lines.

Operation

Successful interconnection operation between several operating companies under different ownership has been accomplished in the Southwest. The total interconnected network is normally operated in four groups, Arkansas, Louisiana, Mississippi, and eastern Texas in

one group; the balance of Texas and southwestern Oklahoma in a second group; the balance of Oklahoma and northwestern Arkansas in a third group; and Kansas and Missouri in the fourth group. The largest group is that in Texas where seven large operating companies under five different ownerships normally operate connected.

The rapid industrial growth of Texas has been the result of this interconnected system, especially in the arid regions of west Texas where transmission service is necessary to transmit the energy from distant plants located where circulating water is ample and an economic supply of fuel is obtainable.

Future Problems

On account of the great distances covered by single circuit or loop transmission lines and the remote location of base load plants, greater dependence on transmission line service is a necessity. The future engineering development must take into account the delivery of energy to the customer at the same general costs experienced elsewhere by increasing the reliability of the present and future transmission systems as well as the development of more economic plants to overcome the longer transmission distance between power supply and consumption.

The engineers in the Southwest are actively at work on these problems and through studies now in progress are keeping pace with similar work throughout the country to determine the proper construction to render the maximum service.

Future Interconnection

The future interconnections in the Southwest will require greater capacity lines and voltages in the 132,000-volt class to shift the increasing blocks of energy; lines designed with higher flashover voltage characteristics; use of regulating transformers with tap changers which may be adjusted under load and the use of synchronous condensers to deliver the voltage regulation required on such long lines as well as the design of more economic plants, and most important of all, interconnection contracts which will make the maximum economic use of the combined facilities.

The future holds forth more reliable transmission service, increasing number of interconnection points, higher voltage and higher capacity per single transmission circuit, better voltage regulation methods, more steam plants with larger economic units located where circulating water and cheap fuel is ample, large hydro plant developments and better contractual cooperation in the operation of the combined plants to give the customer the maximum service at lowest possible cost.

Bare Wire Overhead Distribution Practise

BY M. C. MILLER[1]

Non-member

Synopsis.—An appreciable saving may be made in construction of overhead distribution systems by the use of bare conductors in the place of weatherproof conductors. The reliability of the system will be considerably increased with lower maintenance and operation costs. Bare conductors have practically unlimited life and when removed can be reinstalled as new wire resulting in a reduction of depreciation.

This paper outlines the advantages of using bare wires and gives also advantages of medium-hard-drawn as compared with annealed conductors.

FOR the purpose of furnishing the electrical industry with data concerning the use of bare wire and to assist in choosing between bare and insulated wires for overhead distribution systems this paper was prepared. It shows relative costs of construction, maintenance, and depreciation with condensed data relative to unit weights and costs, and cost of lines and systems with bare and weatherproof wire.

To give a comparison of cost for conductors of the sizes most frequently used in distribution circuits the following costs per 1000-ft. of bare and weatherproof wires are calculated assuming bare at 20 cents and weatherproof at 22 cents per pound.

No. 6 Solid W. P.	$24.64	No. 6 Solid bare	$16.00	Saving $8.64	35%
No. 4	36.08	No. 4	25.20	10.88	30%
No. 2 Str. W. P.	59.04	No. 2 Str. bare	41.00	18.40	31%
No 1/0	93.28	No. 1/0	72.40	20.88	22%
No. 4/0	176.00	No. 4/0	130.60	45.40	26%

An average saving on a number of distribution systems would be about 25 per cent in cost of copper conductors if bare wire were used instead of triple braid weatherproof wire.

The installation costs of bare wire as compared to triple braid weatherproof do not vary directly with the weight. On short extensions of one or two or three spans the labor costs would be about equal, with some savings up to 15 per cent or 20 per cent on longer lines where the lesser weight of bare wire saves on transportation, splicing and setting up reels, etc.

Construction men who have been installing and maintaining bare copper conductors for lighting and

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power secondaries, series street lighting circuits and primaries, 2300 volt to 12,000 volt, express a very definite preference for it over the weatherproof wire.

To operate satisfactorily it must be put up right, sagged correctly, and guyed sufficiently, but once put up right it does not stretch and cause excessive sag which periodically must be pulled up or re-sagged, resulting in a large saving in maintenance costs.

No increase in horizontal spacing is necessary as the smaller sag required for bare conductors reduces the possibility of their swinging together. It has been found desirable, however, to provide additional vertical spacing where bare conductors are installed on vertical secondary racks and 12-inch separation eliminates any possibility of conductors getting together. Eight-inch spacing has been used in many places with no report of trouble from this cause. This increased spacing uses up a foot more of pole height but very seldom requires a five foot higher pole.

The life of weatherproof wire is comparatively short and it is often necessary to replace it with new wire after 10 to 20 years in service. The life of bare copper wire is unlimited. When weatherproof wire is removed from service after 10 to 20 years it usually has to be scrapped as the weatherproofing is deteriorated to such an extent that it is not practicable to reinstall it. Bare copper wire removed is worth practically the same as new wire and may be reinstalled. These two features alone will justify the use of bare copper wire.

In many communities there is an ordinance requiring the use of insulated wires and weatherproof wire is often accepted by inspectors in such communities as meeting these requirements. When such ordinances exist steps should be taken to have them changed. The word insulation might be assumed by the courts to mean insulation sufficient to protect against voltage carried by the conductors. This was practical when the industry was in its infancy and many of the existing electrical ordinances were made at that time. Bare wire has been used in many instances even where insulated wire is required. This has been permitted as it is realized that it is impractical to comply economically with such an ordinance and install wires insulated for voltages from 2300 to 13,000 volts.

Comparative estimates for constructing an 11-kv. distribution system in a small town to serve 60 customers show a saving of 9.5 per cent in total construction cost by using bare in place of weatherproof wire. The saving in cost of conductors is 30 per cent, poles 9.4 per cent and labor 5 per cent. An estimated cost of a mile of No. 4 weatherproof medium hard drawn copper three-phase, 2300-volt line using 35-ft. poles spaced 200 ft. is $1625.00; No. 4 medium hard drawn bare using 35-ft. poles spaced 300 ft. is $1133.00, or a saving of $492.00 or 30 per cent in total cost of bare as compared to No. 4 weatherproof conductors. To [illegible]arize the above advantages in using medium [illegible]rawn bare conductors for general distribution [illegible]tion:

Saving in initial investment cost of conductors may be from 15 per cent to as high as 30 per cent; poles and attachments 5 per cent to 10 per cent; labor 5 per cent to 20 per cent; with a total saving of from 15 per cent to 30 per cent on rural lines and 5 per cent to 10 per cent on complete distribution systems.

Yearly maintenance costs are 15 per cent to 25 per cent less for the reason that conductors do not have to be resagged frequently and there are less outages caused by breaks and conductors swinging together and burning down.

Life of conductors is conservatively three or four times that of weatherproof.

Practically no depreciation occurs in conductors; when salvaged they have practically the same value as new.

Hazard to linemen is not increased as they are necessarily more careful. Hazard to general public is greatly reduced as lines do not break as frequently.

General appearance is greatly improved.

Medium hard drawn has decided advantages over annealed copper wire, having greater strength allowing greater spacing of poles, and considerable savings in construction cost.

The use of bare medium hard drawn copper for overhead distribution systems conductor is worthy of consideration. It has been used on a number of systems in small towns and cities for a sufficient length of time to prove its worth.

Advantages of Medium-Hard-Drawn over Annealed Conductors

In designing or replacing distribution lines another point arises which is worthy of consideration, namely the economy of using medium-hard-drawn instead of annealed wire. Medium hard drawn copper conductors have many advantages over annealed wire, principally on account of the greater strength, being about 25 per cent in No. 1/0, No. 2/0, and No. 4/0 sizes and 35 per cent to 45 per cent in No. 8 to No. 2 sizes. This increase in strength in the smaller sizes allows an increased spacing of poles in urban and rural districts, and in densely built up districts provides an added factor of safety which is very desirable as it affects hazard to the general public as well as reliability of service and maintenance costs.

There is a very slight difference in electrical characteristics, the resistance of medium hard drawn being 1 to 1.5 per cent greater than that of annealed copper wire, which is negligible in distribution system calculation.

Joints in or taps to medium hard drawn copper wire used for overhead lines should not be soldered because annealing of the copper and decreasing its strength would result. There is a number of solderless connectors available. The cost of these installed is usually less than that of a good soldered connection. Various types have been in use for a number of years and no trouble has been experienced from these connectors

working loose and causing loose connections. They are more flexible then soldered connections and are of great assistance in replacing conductors, disconnecting taps, services, etc.

The increased working tensions of medium hard drawn copper conductors require more adequate guying to eliminate possibilities of anchors and guys creeping and conductors becoming slack.

Abridgment of

Influence of Temperature on Large Commutator Operation

BY F. T. HAGUE[1] and G. W. PENNEY[1]
Associate, A. I. E. E. Associate, A. I. E. E.

Synopsis.—The paper discusses the operating characteristics of large commutators. It is pointed out that initially many cases of blackened and burned bars are caused by a slight roughness which causes irregular commutation and a slight sparking which when once started gradually becomes worse. The requirements of the surface of a high-speed commutator are discussed, showing that radial variations of the order of one ten-thousandth of an inch between adjacent bars may give serious trouble. Some causes of roughness are discussed, showing that temperature is a major factor, but that redesigning the commutator to reduce the temperature does not necessarily cure the trouble, and may actually give poorer performance. Some methods of commutator testing are described with typical records showing the performance of various types of construction.

The question of safe temperature limits is then discussed. It is maintained that the question of the permissible temperature limits is entirely unlike that of insulated windings, since the materials used are not injured by temperatures considerably above the present limits. The permissible limit of a commutator is determined by its mechanical construction. Low temperature limits may lead to illogical designs, since large heat dissipating surfaces are required which may give higher stresses and larger expansion effects, which may be more harmful than higher temperatures. A temperature limit based on operating characteristics would be more satisfactory.

DURING the past five years, considerable experimental work on large commutator performance and characteristics has been under way, and many different types of construction have been investigated and compared. Much information of value to designers has been accumulated and this information has led to a clearer understanding of the desirable characteristics of commutators and the influence of operating temperature on performance.

The paper, as indicated in its title, will deal with the subject from the standpoint of large commutators usually found only in power station and substation machinery.

In all types of construction, the heating of the commutator is inevitable because of the mechanical friction of the brushes and the electrical loss at the contact. In most electrical apparatus, the permissible temperature is determined by the temperature at which the insulation is permanently injured, but in large commutators the materials are not injured by temperatures considerably above the limits commonly applied. There are other very important effects of temperature, but this is ordinarily not in the nature of a definite limit fixed by the materials but rather as a limit based on the construction features of the commutator and particularly its ability to withstand the change in dimensions caused by a change in temperature. For this reason the authors believe that a different type of temperature limitation should be used for commutators from that used for apparatus where the temperature is limited by the point at which the material is injured. This paper will be devoted to a general discussion of the nature of the temperature limitation of commutators.

The primary function of the commutator is to make contact with the brush. A certain variation in the contact drop is permissible, but as will be shown later, some commutators reach a condition where the brush cannot transmit direct current to the bars without vicious sparking, even when no commutation is involved. Under such conditions, satisfactory commutation is impossible. With the bars moving at a speed of a mile a minute or more, the commutator surface, if the brushes are to maintain uniform contact with all bars, must be very smooth.

MEASUREMENT OF COMMUTATOR SURFACE CONDITIONS

Any progress in science or engineering is dependent first on knowledge of the facts. Suitable measuring instruments and methods are fundamental to progress. This study of commutator design and performance made very slow progress until a satisfactory device for measuring commutator surface conditions was developed.

Since the condition of a commutator surface may change with speed and temperature, it must be measured at full speed and operating temperature. The measurement of a variation of the order of one ten-

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thousandth of an inch between adjacent bars running at a surface speed of over a mile a minute is beyond the range of ordinary instruments. Because of the difficulty in measuring this mechanically, and since we are primarily interested in the effect of the surface condition on the brush contact drop, the measurement of this contact drop seems to be the most logical means of

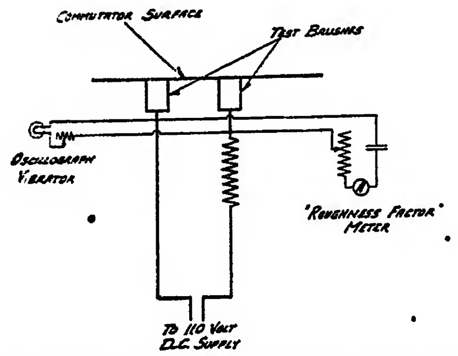


FIG. 2—WIRING DIAGRAM FOR BRUSH DROP TEST

Power circuits are shown by heavy lines and instrument circuits by light lines. The oscillograph and roughness-factor meter are both shown connected

determining the surface condition. Fig. 2 shows the wiring diagram for a scheme of doing this which will be called the "brush drop test." Fig. 4 shows a small commutator set up for the test. In this test, two or more brushes are mounted in line so as to make contact with the same commutator bar. Current is passed from one brush to the bar and back through one or more brushes in series with sufficient resistance, so that practically constant current is maintained. The double-contact drop is recorded by an oscillograph. In this way, the surface condition of the commutator can be studied during heating and

FIG. 4—COMMUTATOR SET UP FOR BRUSH DROP TEST

cooling, and for various speeds. If a timing contact is used as a second record on the oscillogram, the position of any roughness of the commutator can be located.

If it is not necessary to locate the bars giving trouble, but only to determine the average operating condition of the surface, then the "roughness factor meter" may be used instead of the oscillograph. Fig. 2 shows the wiring diagram for the brush drop test with both the oscillograph and the "roughness factor" meter connected to measure the brush drop. It consists of a large capacity condenser, variable resistance, and thermal milliammeter all in series. The condenser has sufficient capacity to offer only a negligible impedance to fluctuations in brush drop. For a perfectly uniform contact, the reading is zero, but in case the brush drop fluctuates, the current through the meter is limited by the resistance in series. The product of the resistance in ohms by the current in amperes is called the "roughness factor." It is the r. m. s. value of the fluctuations in brush contact drop in volts and is a measure of the surface condition of the commutator. With a good surface, it should be 0.15 or less, while with a bad surface it may rise to several volts.

This method of measurement does not, of course, give bar movements in inches, and in the case of eccentricity, a movement of several mils may give no indication; but since we are concerned with the uniformity of the contact drop, it does indicate the things in which we are interested. Because of its sensitivity, reliability, and simplicity, this test has been extensively used to

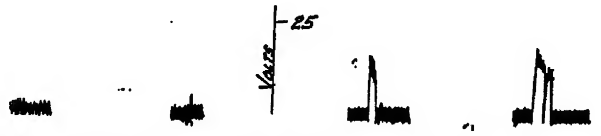


FIG. 6—CONTACT DROP OBTAINED WITH FOUR DIFFERENT BRUSH AND BRUSH HOLDER ARRANGEMENTS

The cut was traced from oscillograms showing contact drop passing over the same surface roughness, only the brush and holder being changed

study commutator surface conditions. Usually, the commutator is ground and the test brushes mounted. The commutator is then heated by narrow belts lined with maple blocks. These are so arranged that they do not strike the surface at points where the test brushes will bear. This method gives the surface heating and temperature distribution closely approximating service conditions. It also give additional heat on any bar which tends to become high combined with considerable mechanical vibration, so that it is a very severe test which should disclose any trouble likely to develop in service.

THE CAUSES AND EFFECTS OF COMMUTATOR ROUGHNESS

The complete paper discusses briefly the question of the brush rigging, showing that this is another problem of major importance, since a wide variation in contact conditions can be obtained with a given commutator surface, only the brush and holder being changed. Fig. 6 is one example showing the importance of the brush and holder. But even with the best brush and holder, a very smooth commutator surface is still required.

In discussing the effect of roughness, it is pointed out

that it is very difficult to determine the effect of roughness from the commutation of the machine, since a slight bar movement may occur which produces only a slight sparking at first, but which gradually produces a smutting or burning of the bar, which still further disturbs the brush action until a serious sparking results. This effect may continue even though the bar movement originally causing the trouble has disappeared.

Because little information has been available concerning the properties of mica, it has frequently been blamed for many troubles due to other causes. The requirements of mica and methods of testing are described in the paper. Upon first thought, centrifugal force will usually be considered to be the most serious cause of commutator roughness. However, tests have shown that it is relatively easy to make a commutator that will remain perfectly smooth at all speeds up to reasonable overspeed, *if tested cold.*

The effect of temperature is usually far more serious in commutator operation than centrifugal force. A number of the effects of temperature which produce roughness are discussed in the complete paper showing that they usually have the nature of a bending or warping of the bar.

It might seem that the solution of the problem is a low temperature rise. However, a low temperature rise requires a large surface for heat dissipation. For any given design, this usually requires a longer bar. The deflections causing roughness usually are of the nature of a bending or bowing of the bar which increases with the second to the fourth power of the bar length, depending on the type of support. Then, since the deflection increases as a power of the length while the temperature decreases only with the inverse of the first power of the length, for any given type of construction, the roughness may be increased, rather than decreased by lowering the temperature rise. A more logical method of attack seems to be to alter the construction so as to reduce the roughness for a given temperature rise.

Types of Commutator Performance Under Influence of Temperature

I. Ideal. The ideal commutator should stay perfectly smooth under all operating conditions. A commutator of 23 in. active face length (26½ in. total bar length) and 5500 ft. per min. peripheral speed was heated to 140 deg. cent. (115-deg. cent. rise) using a belt lined with maple blocks and tested while cooling. Records at 115-deg. cent. rise and when cooled to room temperature show that a temperature rise far above present limits did not produce any measurable roughness in this commutator.

II. Fair. A commutator which becomes rough when heated to the overload temperature, but returns to a smooth condition when cooled, is classed as fair. This might show some sparking at overload, but if this is not of sufficient duration to burn the bars, the performance should be satisfactory when the load is reduced.

III. Bad. A commutator which when heated either to an operating or even a slight overload temperature, becomes rough and fails to return to a smooth condition on cooling is bad, because the surface must be re-ground to put it in a satisfactory condition.

Commutator Seasoning

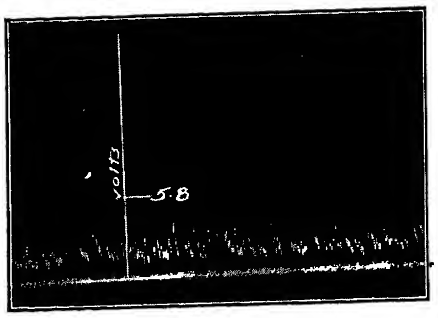
Practically all large commutators if tested immediately after assembly and before any heating treatment would show the performance just referred to as bad. This is due to the nature of the copper and mica, both of which tend to yield when first subjected to stress and temperature. The gradual yielding of the copper and mica under stress and temperature until finally a stable condition is reached is referred to as seasoning.

In a low-speed commutator, a sufficiently stable condition may be reached by merely repeated heating and tightening. In a commutator with higher rotational stresses these stresses must act on the commutator for a considerable time during heating and cooling before a stable condition may be reached. Originally, this was done by loading the machine with the brushes set off neutral to give excessive heating. Now, methods have been developed for seasoning the commutator before it is even assembled on the machine. In some cases this may be accomplished by merely rotating in an oven. In other cases, a more severe method known as "block seasoning" may be required. This consists in heating the commutator by the friction of belts lined with maple blocks. This gives the surface heating and temperature distribution approximating operating conditions, combined with mechanical vibrations.

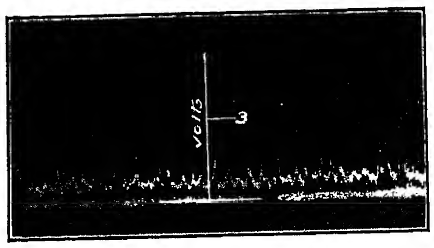
The most obvious effect of seasoning is to eliminate the yielding of the mica, but in the best type of high-speed commutator the copper must be permitted to yield slightly to allow it to conform to any irregular mica surface. Due to the peculiar nature of copper, this yielding will take place only partially during assembly. The rest will take place as a slow creep during the seasoning period. Tests have shown that the mica now used reaches stability in about 30 hours of seasoning at 150 deg. cent., while in some cases the copper may require 150 hours, even when accelerated by overspeed and added building force.

Fig. 14 shows the results obtained by block seasoning. Each record shows the roughness produced by a heating and cooling cycle. In the first test (Fig. 14A), taken after a short period of block seasoning, the surface was very rough, so that only a small current could be used on the test brush. The roughness is shown by the irregularity of the contact drop. The second test (Fig. 14B) shows an intermediate condition. In the test after the final block seasoning the surface remained

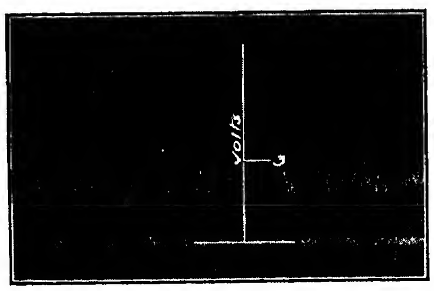
almost perfectly smooth so that full current was used on the test brush giving the higher normal contact drop evident in Fig. 14c. The roughness is indicated by the irregularity of the contact drop and this irregularity is almost independent of the test current used. The number and value of the "peaks" in the oscillogram are the significant factors, rather than the average value of the voltage drop. Even after all of these precau-



A



B



C

Fig. 14—Effect of Seasoning

A—Commutator block seasoned for a short period and then ground smooth while cold, heated for 10 hr., and record taken after cooling to room temperature

B—Given additional period of block seasoning, ground smooth while cold, heated, and record taken when cold

C—Same as "b" except after an additional period of block seasoning

tions, there may be some minute bar shifting during the first few months of operation, so that more maintenance is to be expected during this period than after the commutator has been in service for some time. A large commutator is one of the few mechanical devices which improve with use during early years of service.

Safe Temperature Limits

A rational type of commutator design and construction may have a safe limiting temperature of 125 to 150 deg. cent. without developing surface roughness, whereas other types of construction may be unsuited to limits as low as 75 deg. cent. The ability to withstand repeated temperature cycles without developing roughness determines a commutator's safe limiting temperature. The problems involved are entirely mechanical in nature, and the practise of the present rules in setting an arbitrary low-temperature limitation does not meet the requirements of the situation.

The present standard of a temperature rise limit and load test is inconclusive. It is made ordinarily at a low ambient temperature and does not show what trouble might develop from the additional total temperature obtained with the higher ambient temperature permitted by the Standards, and it cannot usually be of sufficient duration to discover effects that may gradually accumulate due to very slight initial mechanical disturbances. The present practise of setting a temperature limit as a criterion for a mechanical problem is objectionable, in that it results in design practise which actually encourages the development of operating trouble which it purports to prevent. Low limiting temperature, such as the present limit of 60 deg. cent. rise on converter commutators, requires large heat-dissipating surfaces on the commutator which frequently necessitate extra long commutators, one or more sets of ventilating vanes, and other characteristics which lead to high stresses, large expansion effects, etc., that may be more detrimental to operation than a higher limiting temperature. A physically large commutator having high mechanical stresses and high surface speed that will operate at a low temperature when newly ground and in good mechanical operating condition, may well be a much less satisfactory commutator to the operating engineer than a physically smaller commutator which, under the same conditions of loading, operates at a considerably higher temperature but stays dead smooth under its maximum operating temperature range. Adherence to the present standards forces the designer to use a highly stressed commutator with high peripheral speed that may be far more detrimental to good operation and low maintenance costs than would be the higher temperature rise resulting from a smaller lower stressed commutator.

A better measure than the load test, although scarcely practical in many cases, would be a repeated cycle test with the maximum ambient temperature. Satisfactory performance would be indicated by no appreciable increase in sparking with successive heat cycle tests. A less expensive and therefore more feasible test for determining the permissible operating temperature would be a "brush drop" or equivalent test, which could be made at the maximum temperature and would have the sensitivity to show any slight roughness which might in time give trouble.

ILLUMINATION ITEMS

Submitted by
The Committee on Production and Application of Light

LIGHT THERAPY

H. P. Gage, Ph. D.*

Light therapy, or more properly speaking, radiation therapy, has for some years been a useful tool in the hands of physicians. It is rapidly coming into popular favor. Countless home treatment devices have been placed on the market and are in use. The effectiveness of radiation therapy, when intelligently used, has been demonstrated by a vast accumulation of evidence.

Some of the beneficial results of light therapy are due entirely to a fairly deep penetration of radiant energy, thereby heating the deeper tissues of the body, causing improved circulation and relief of congestion. Lumbago and numerous "aches and pains" disappear after an application of radiant energy. Radiation capable of tissue penetration must be of a wavelength greater than about 0.6 μ in the red or it will be quickly absorbed by the hemoglobin of the blood, and must be of lesser wavelength than 1.5 μ in the near infra red or it will be absorbed by the water content of the outer layers of the skin. The temperature radiation whose maximum lies in the near infra red at a wavelength of about 1. μ would thus be the most efficient, and as has been pointed out by Luckiesh,[1] some form of high power tungsten filament lamp is the most efficient. For a home treatment lamp, however, the carbon filament lamp has a factor of safety in its favor. Greater energy absorption in the superficial layers of the skin will serve as a check on possible injury due to overheating the deeper tissues before the patient becomes aware that anything is happening.

Two grades of radiation therapy may be distinguished: The high-power, high-speed therapy, having inherent dangers of overdosage should be attempted only by the experienced physician. The short time of treatment required with strong radiation makes it available in the office of the busy practitioner; for example, ultra violet radiation of sufficient intensity to cause an erythema, or sunburn, sometimes of painful intensity, serves as a counter irritant and stirs up healing of wounds and resistance to infection in sluggish tissue. Such violent measures are to be avoided by the inexperienced. Mild, slow-speed radiation therapy may be indulged in by the general public at its pleasure with little fear of danger and considerable promise of benefit. Radiation of the general level of summer sunshine may be considered as the dividing line between high-speed and slow-speed radiation. Summer sunshine at noon has too much heat intensity to be risked by those not used to it for long periods without some protection. The ultra violet intensity of the sun is too great for comfort and has led to painful sunburn, sickness and occasional death by the uncautious over-exposure of some people not previously acclimated to it.

*Chief Optical Division, Corning Glass Works Laboratories.

Rickets

The effect of ultra violet in the prevention and cure of rickets has almost the certainty of a chemical reaction. Control of calcium metabolism by vitamin D contained in cod liver oil, specially irradiated foods, etc., or by direct ultra violet irradiation, is essential to growing children, and pregnant and nursing mothers. The region of ultra violet has been experimentally determined as shorter than 0.313 μ.[2,3,4] As sunlight even during the winter months at 42 deg. latitude is useful, and direct summer sunshine is highly effective, the extremely short wavelength region transmitted by the earth's atmosphere, *i. e.*, radiation between the limits 0.31 μ and 0.29 μ[11], is known to be highly efficacious. Skyshine is effective, although less so, than direct sunshine.[5] To have any effect, however, practically the entire sky must be visible from the position of exposure. The relatively negligible fraction of the sky hemisphere to be seen through an ordinary window opening is ineffective in curing or preventing rickets according to the experiments of Doctor F. F. Tisdall and the calculations of Doctor Janet H. Clark.[6]

Direct sunshine, even in the winter months, and even when passing through glasses transmitting but 25 per cent (after solarization) of the ultra violet of the 0.302 μ region is capable of preventing rickets in rats[6] and chickens[7] provided a long enough time of exposure is resorted to. With human infants, during the winter at Boston the sun shining through the best available ultra violet transmitting materials, fused quartz and Corex A window panes has cured rickets in the cases of both white and negro children.[8]

A quartz mercury arc consuming about 250 watts at the arc placed 36 in. above the floor of the pen in which the chickens were treated gave approximately the same protection as direct midsummer sunshine when used about eleven minutes.[9]

Other Therapeutic Effects

It would be a mistake to assume that all therapeutic effectiveness of ultra violet is confined to the region needed for the curing rickets.

Pernicious anemia is apparently caused by a specific toxin.[10] The toxin can be destroyed by ultra violet and violet of wavelengths between 0.2536 μ and 0.405 μ, 0.313 μ being the most effective for equal energy. Several times the effectiveness is secured by an addition of chemically pure eosin. In living patients, especially after introducing chemically pure eosin into the blood stream, ultra violet treatments are capable of destroying this toxin so that it can no longer kill the red blood cells as fast as they are formed. The patient recovers, the recovery apparently being permanent, or at least of several years duration.

Colds are reported as less frequent and less severe when ultra violet treatments are given. The desirable dosage and expected advantages have yet to be fully worked out.

Tuberculosis is such a treacherous disease that treatments must be made under the supervision of an experienced physician. Surgical tuberculosis, such as that of the skin (lupus), joints, glands and peritoneum can be aided or cured by ultra violet therapy. Pulminary tuberculosis in the active stages may, on the other hand, be deleteriously affected. In many of the best sanitariums, however, carefully controlled ultra violet treatments are given and doubtless are of definite benefit in many cases. Patients returned to their homes could continue ultra violet treatments, once the method, apparatus, desirable dosage, etc., had been worked out by the skilled physician and learned by the patient.

There are certainly bodily conditions which are aggravated by the use of ultra violet and the practising physician must be familiar with these, especially when employing the high-speed erythema doses. Drawbacks and disadvantages, debunking statements, and exposures of worthless apparatus will from time to time appear to dampen the ardor of the over enthusiastic, but sufficient sound biological and medical evidence is available to justify a firm belief in a very real benefit to be derived from an intelligent use of radiation therapy, both by the physician and in the home.

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3. Alfred F. Hess, A. M. Pappenheimer and M. Weinstock, "A Study of Light Waves in Relation to their Protective Action in Rickets." *Am. Medical Association*, Vol. 80, pp. 687-690, March 10, 1923.

4. Geo. H. Maughan, "Ultra Violet Wavelength Valuable in the Cure of Rickets in Chickens." *Am. J. of Physiology*, Vol. 87, pp. 381, Dec. 1928.

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9. G. F. Heuser and L. C. Norris, "Rickets in Chicks," *Poultry Science*, Vol. VIII, p. 89, Dec.-Jan. 1928-29.

10. David I. Macht and William T. Anderson, Jr., "Clinical and Experimental Studies on Phototherapy in Pernicious Anemia," *The J. of Pharmacology and Experimental Therapeutics*, Vol. XXXIV, p. 365, Dec. 1928.

11. Charles Fabry and H. Buisson, "A Study of the Ultra Violet End of the Solar Spectrum," *Astrophysical J.*, Vol. LIV, p. 297, Dec. 1921.

REPORT ON USE OF INCANDESCENT LAMPS IN MOTION PICTURE PHOTOGRAPHY

By R. E. Farnham*

A census taken about the first of February 1929 shows that of some 60 or more pictures in the process of being photographed, approximately 60 per cent were being made with incandescent lamps, an increase from 25 per cent as of July 1, 1928. The general practise of the studios has been to make their sound pictures entirely with incandescent lamps and to use the former illuminants for the silent pictures.

The Universal Studio has recently completed the filming of the picture "Broadway," taken from the popular New York success of the same name. The largest indoor set ever constructed was used for the cabaret scene. This scene, together with several others immediately adjacent, and really becoming a single large set, was lighted entirely with 4800 incandescent lamps whose wattage totaled 3,900,000. The largest part of this energy was employed in regulation motion picture photographic lighting equipment. There were, however, many thousands of lamps of lower wattage employed for decorative effects. This large set is indicative of a general trend throughout all of the studios to employ many low-wattage lamps for decorative effects in large and miniature signs, in table lamps, wall brackets, and automobile headlamps. Lamps are even being operated under water.

The 2000-watt G-48 bulb lamps in the 18-in. parabolic reflector housing, and the 5000-watt G-64 bulb lamp in the 24-in. housing continue to be the most popular types of lighting units, while the 1000-watt and 1500-watt PS-52 bulb lamps, in high-efficiency glass reflectors, are extensively used for general illumination. And 10-kw. lamps in 36-in. parabolic reflector units are beginning to be used. One of the manufacturers of the 18-in. reflector unit has shortened the housing to about one-half its former length, with the result that 30 per cent more light is emitted when the unit is adjusted for wider beam spreads. Another lighting equipment manufacturer is developing a large glass reflector for general illumination, which has an improved distribution and operates the lamp in a more favorable position than the present types. Also, this unit is being designed so as to use the 2500-watt PS-52 bulb lamp which is now becoming popular where it is desired to increase the quantity of light without an increase in the number of units.

The lamp manufacturers are now incorporating an internal mechanical cleaner in the form of a coarse tungsten powder in the 5- and 10-kw. lamps by which the bulb blackening can be removed from time to time during the life of the lamp. The result is that the light output can be maintained nearly at its initial value throughout the life of the lamp and this permits these lamps to be operated at a higher efficiency.

*National Lamp Works of General Electric Company.

Institute and Related Activities

The 1929 Summer Convention

A NOTABLE PROGRAM OF PAPERS, ENTERTAINMENT, AND RECREATION FEATURES

THE 1929 Summer Convention will be one of the finest ever held by the Institute. The Convention will be held June 24 to 28 with headquarters at the New Ocean House, Swampscott, Mass. All features have been considered which might make an enjoyable and worthwhile meeting.

A selection of particularly high-grade technical papers has been made. These will deal with very live topics such as distribution systems synchronized at the load, automatic synchronizing, communication, electrical transportation, electrical machinery, outdoor hydrogen-ventilated synchronous condensers, loading transformers according to temperature, shielding in electrical measurements, electrical heating elements, high-frequency electrical tools, etc. The titles of the individual papers are given elsewhere in this announcement.

Reviews of developments in all electrical fields will be presented in the annual reports of the Technical Committees of the Institute.

PANORAMIC VIEW OF MARBLEHEAD HARBOR

No locality is richer in opportunity for trips of engineering, scenic and historic interest. A large number of trips have been arranged.

For the recreational side of the program, a most enthusiastic local Convention Committee is planning many enjoyable events. Swampscott is an ideal place for a convention, combining seashore and country with excellent hotel facilities. Those who attended the 1923 Summer Convention at Swampscott remember the very enjoyable and successful meeting held at that time and it may be prophesied that the coming meeting will be equally as good.

Golf and tennis, a reception, a banquet, dancing, and card playing will be some of the entertainment features. More information, particularly on the golf tournament, is given in later paragraphs.

For the ladies who attend the meeting a special program has been arranged in addition to the many features on the regular program which they will enjoy.

The business side of the convention will include the Annual Meeting of the Institute, a report of the Committee of Tellers on election of officers for 1929-1930, the address of the President and presentation of prizes for papers.

The first Lamme Medal, which was awarded some months ago, will be presented to the medalist, Mr. A. B. Field of England.

There will be a lecture on the evening of June 25, by Dr. Harlowe Shapley; also several addresses at the banquet on June 26.

As customary at Summer Conventions, the first day will be devoted to conferences of Institute officers and delegates held under the auspices of the Committees on Sections and Branches. All members are invited to these conferences.

OUTLINE OF PROGRAM

(Eastern daylight-saving time is indicated throughout this program)

Monday, June 24

9:00 a. m.	Registration
10:00 a. m.	Conference of Officers and Section Delegates
12:30 a. m.	Section and Branch Delegates Luncheon
2:00 p. m.	Officers and Delegates Conference (continued)
2:00 p. m.	Sports as scheduled
2:00 p. m.	Inspection trips
4:00 p. m.	Branch Delegates Meeting
4:30 p. m.	Afternoon tea
8:00 p. m.	Informal dancing, cards

Tuesday, June 25

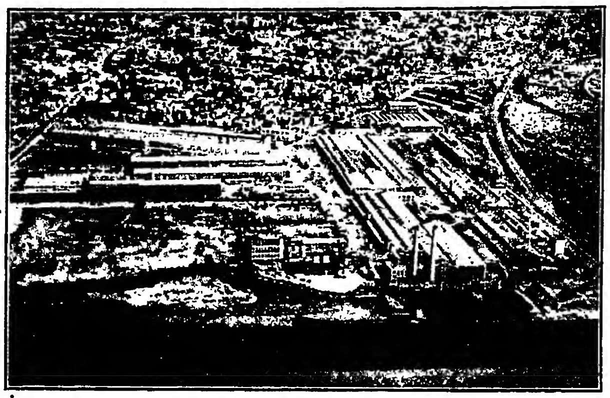
9:00 a. m.	Registration
9:30 a. m.	Annual Business Meeting Address of Welcome, Report of Board of Directors (in abstract); Report of Tellers; Introduction of, and response from, the President-Elect; Presentation of Prizes for Papers; President's Address
10:30 a. m.	Two Technical Sessions, (a) Distribution and Power Plants; (b) Transportation
1:00 p. m.	Past-Presidents and Directors Luncheon.
2:00 p. m.	Trips as scheduled
2:00 p. m.	Sports as scheduled
2:30 p. m.	Board of Directors Meeting
4:30 p. m.	Afternoon tea
8:00 p. m.	Convention Lecture—Prof. Harlowe Shapley of Harvard
9:15 p. m.	Reception—dancing, cards

Wednesday, June 26

9:00 a. m.	Social hour
9:30 a. m.	Technical Committee Reports—2 Parallel Sessions
2:00 p. m.	Technical Session (miscellaneous subjects)
2:00 p. m.	Trips as scheduled
2:00 p. m.	Sports as scheduled
4:30 p. m.	Afternoon tea
7:00 p. m.	Convention Banquet Presentation of Lamme Medals. Speakers, entertainment, dancing, cards

Thursday, June 27

9:00 a. m. All-day Trip to Rye Beach, Maine
9:30 a. m. Sports as scheduled
2:00 p. m. Final round, Mershon Cup play
4:30 p. m. Afternoon tea
8:30 p. m. Presentation of sports prizes, entertainment, dancing, cards



Airplane View—River Works, General Electric Co.

Friday, June 28

9:00 a. m. Social hour
9:30 a. m. Technical Sessions (a) Electrical Machinery, (b) Shielding in Electrical Measurements
2:00 p. m. Trips as scheduled
2:00 p. m. Sports as scheduled
3:00 p. m. Start of Post-Convention Excursion through White Mountains
4:30 p. m. Afternoon tea
8:00 p. m. Dancing; cards

LADIES' PROGRAM

The ladies are invited to all events, the following being listed as of special interest to them.

Monday, June 24

2:00 p. m. Putting Contest at New Ocean House—or
2:00 p. m. Drive to Boston Art Museum
4:30 p. m. Afternoon Tea
8:00 p. m. Informal Reception
8:30 p. m. Dancing, cards

Tuesday, June 25

10:00 a. m. Drive to points of historical interest in Boston, thence to Wayside Inn, Sudbury
1:00 p. m. Luncheon at Wayside Inn, return trip through Lexington and Concord
4:30 p. m. Afternoon Tea
8:00 p. m. Lecture—Prof. Harlowe Shapley
9:15 p. m. Reception—dancing, cards

Wednesday, June 26

10:00 a. m. Drive to Salem and Marblehead, with visits to Old Witch House and House of Seven Gables
2:30 p. m. Bridge at New Ocean House
7:00 p. m. Banquet, Presentation of Lamme Medal, entertainment, dancing, cards

Thursday, June 27

9:00 a. m. All-day trip to Rye Beach
8:30 p. m. Presentation of sports prizes, entertainment, dancing, cards

Friday, June 28

2:00 p. m. Drive to Plymouth
3:00 p. m. Start of Tour through White Mountains
4:30 p. m. Afternoon tea
8:00 p. m. Dancing, cards

The golf links of the New Ocean House will be open to the ladies and a tournament will be arranged if enough signify their intention to enter.

There will also be opportunity for tennis.

Technical Sessions

June 25

Distribution and Power Generation

10:30 a. m. Symposium on "Synchronized at the Load"

I. *A Fundamental Plan of Power Supply*, A. H. Kehoe, United Electric Light & Power Co.

II. *Calculations of System Performance*, S. B. Griscom, Westinghouse Electric & Mfg. Co.

III. *System Tests and Operating Connections*, H. R. Searing and G. R. Milne, United Electric Light & Power Co.

Automatic Transformer Substations of Edison Electric Illuminating Co. of Boston, W. W. Edson, Edison Elec. Ill. Co. of Boston

Rehabilitation and Rebuilding of Steam Power Plants, C. F. Hirshfeld, Detroit Edison Co.

Application of Induction Regulators to Distribution Networks, E. R. Wolfert and T. J. Brosnan, Westinghouse Electric & Mfg. Co.

Interior of Bellows Falls Station of New England Power Association System

Transportation

10:30 a. m. *Electrification of the Mexican Railway*, J. B. Cox, General Electric Co.

Contact-Wire Wear on Electric Railroads, I. T. Landhy, Illinois Central Railroad Co.

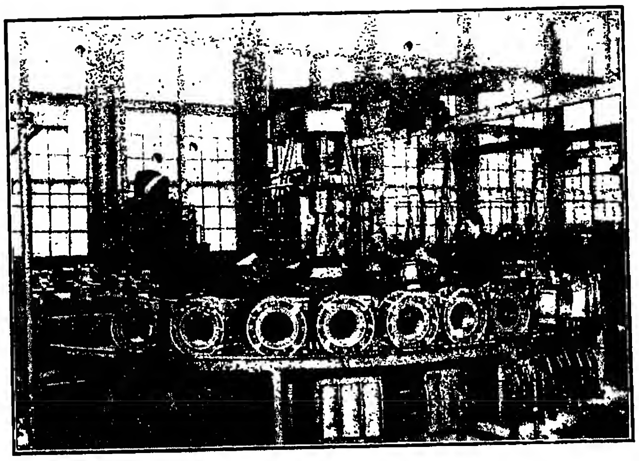
An Electrified Railroad Substation, J. V. B. Duer, Pennsylvania Railroad

D-C. Railroad Substations, A. M. Garrett, Commonwealth Edison Co.

JUNE 26

TECHNICAL COMMITTEE REPORTS

9:30 a. m. About eighteen reports will be presented reviewing the major activities in the fields of the various Technical Committees of the Institute. The reports will be presented in two parallel sessions.



MOTOR ASSEMBLING ROOM AT RIVER WORKS OF GENERAL ELECTRIC COMPANY

MISCELLANEOUS

2:00 p. m. *Master Reference System for Telephone Transmission*, W. H. Martin, American Tel. & Tel. Co., and C. H. G. Gray, Bell Telephone Laboratories, Inc.

Electrical Wave Analyzers for Power and Telephone Systems, R. G. McCurdy and P. W. Blye, American Tel. & Tel. Co.

A New Automatic Synchronizer, F. H. Gulliksen, Westinghouse Electric & Mfg. Co.

High-Frequency Portable Electric Tools, C. B. Coates, Chicago Pneumatic Tool Co.

Design of Electric Heating Elements, Edwin Fleischmann, The Niagara Falls Power Co.

JUNE 28

ELECTRICAL MACHINERY

9:30 a. m. *Safe Loading of Oil-Immersed Transformers*, E. T. Norris, Ferranti, Limited

Induction Motor Operation with Non-Sinusoidal Impressed Voltages, L. A. Doggett and E. R. Queer, Pennsylvania State College

Outdoor Hydrogen-Ventilated Synchronous Condensers, R. W. Wieseman, General Electric Co.

Short-Circuit Torque in Synchronous Machines, Without Damper Windings, G. W. Penney, Westinghouse Elec. & Mfg. Co.

Analytical Determination of Magnetic Fields, B. L. Robertson, Pennsylvania State College, and I. A. Terry, General Electric Co.

SYMPOSIUM ON SHIELDING IN ELECTRICAL MEASUREMENTS

9:30 a. m.
1. *Shielding and Guarding Electrical Measuring Apparatus*, H. L. Curtis, Bureau of Standards
2. *Some Problems in Dielectric Loss Measurements*, C. L. Dawes, P. L. Hoover and H. H. Reichard, Harvard University
3. *Shielding in High-Frequency Measurements*, J. G. Ferguson, Bell Telephone Laboratories
4. *Shielding of Cables in Dielectric Loss Measurements*, E. H. Salter, Elec. Testing Laboratories
5. *Precautions Against Stray Magnetic Fields in Measurements with Large Alternating Currents*, F. B. Silsbee, Bureau of Standards
6. *Magnetic Shielding in Electrical Measurements*, S. L. Gokhale, General Electric Co.

Trips

A large number of interesting trips may be taken. Two special trips are being featured, one an all day trip and outing to Rye Beach, Maine, and the other a post-convention tour through the White Mountains.

The all-day outing will be taken on Thursday, June 27, and will prove a most acceptable opportunity for making friends and enjoying the entertainment which will be provided.

The post-convention tour will start on Friday afternoon, June 28, and will end at Greenfield, Mass., or Boston on Monday, July 3. The trip will be through New Hampshire, Maine, and Massachusetts and will take in many beautiful lake and mountain scenes. The complete cost will be $48.50, with return to Greenfield, and $54, with return to Boston. This includes all transportation and hotels (double rooms).

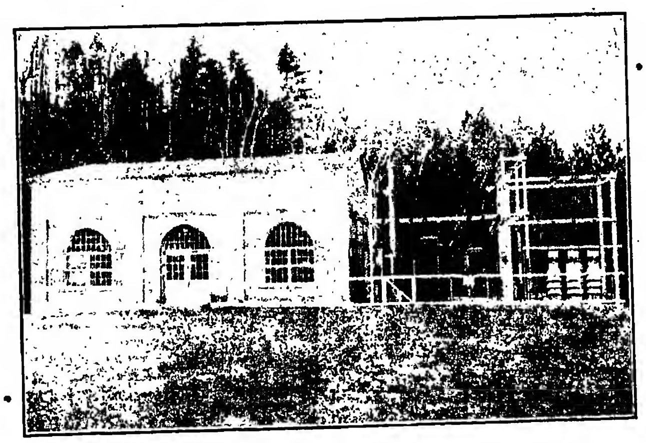
Other trips may be made to colleges, power plants, substations, telephone plants, manufacturing plants and points of historic and scenic interest. Airplane trips will also be available.

Sports

Golf, tennis, swimming, fishing and boating will be available for those who wish to enjoy them.

Both golf and tennis tournaments will be played for the respective Mershon Cups. It is proposed to present the prizes on Thursday evening and in order to accomplish this purpose all competition must be completed before Thursday evening.

On account of the limited time and as the golf competition will be match play, the following information on the golf tournament is given. Special note should be made of the possibility of playing the qualification round on *Monday morning at 8 a. m. or 10 a. m.*



SILVER LAKE HYDROELECTRIC PLANT OF PUBLIC SERVICE CORP. OF VERMONT 675 FT. HEAD. THIS IS BELIEVED TO BE THE HIGHEST HEAD PLANT EAST OF THE MISSISSIPPI RIVER

The golf competition will consist of a qualification round (handicap medal play) of eighteen holes followed by match play (handicap).

The qualification round will be played on *Monday, only*, June 24, 1929. The sixteen low net scores will qualify for the match-play rounds. No green fee will be charged members and registered guests.

A representative of the Committee will be at the Club House at *eight a. m., Monday, June 24*, so that officers, section delegates, etc., who wish may play their qualification round early and still not miss their scheduled meetings. Also those who are not attending the conference may play at 10 a. m. on Monday morning.

In order to avoid conflicts with business meetings and technical sessions, it is the wish of the Committee that play be restricted to the time of scheduled events, namely; Monday a. m. and p. m., Tuesday p. m., Wednesday p. m., and Thursday a. m. and p. m.

Hotels

The following gives information on hotels. Reservations should be made by communicating directly with the hotel selected.

The New Ocean House will be the center of Convention activities. Most of the rooms are double rooms with bath and it is suggested that, as far as possible, members should request reservations in parties of two, since some of the single reservations will have to be sent to the Hotel Preston. Some of the most desriable rooms situated on the ocean side are for three, four or five persons, so that members who make up a congenial party and apply for such a suite, will be assured of desirable rooms. Members who plan to come alone and who signify on their request for reservations that they will share a double room with another member will in general get a more desirable room than if a single room were engaged.

New Ocean House

Swampscott, Mass.

Daily rates per person for room and meals

Room	Number of persons (beds)	With bath	With running water
Single	1	$9–$10	$8–$9
Double	2	$8–$9	$7
Double	3	$7	$6.50
Large	4	$6.50	..
Two*	4	$7.50	..
Two*	5	$7	..
Two*	6	$6.50	..

*Suite of two rooms with bath between.

Rates for Meals only—For non-resident guests, combination tickets for meals taken in one day will be issued as follows:

	In main Dining Room	In Tea Room
Breakfast, Luncheon and Dinner	$5.00	..
Both Luncheon and Dinner	4.00	$2.50
Dinner	3.00	1.50
Luncheon	3.00	1.00

These rates include the Convention Banquet.

Garage space in concrete fireproof garage, $1.00 per day.

Other Nearby Hotels

There will be free bus or auto service between the New Ocean House and the following hotels:

Hotel Prescott, Beach Bluff, Mass., two miles from New Ocean House, rates same as New Ocean House.

Bellevue Hotel, Beach Bluff, Mass., one mile from New Ocean House. Rates per person (including breakfast), single room $5.00; double $3.50.

Deer Cove Inn, Swampscott, $5 per person, with meals.

The Arkhaven, Swampscott, Rates with meals $5–$9 without bath; $6–$11 with bath.

The Priscilla, Swampscott, Rates $2; no meals.

Reduc d Railroad Rates

Reduced railroad rates on the certificate plan will be available for those attending the meeting from practically all points. Also summer tourist fares at a lower rate will be in effect from certain Western States.

By the Certificate Plan the round trip will cost only one and a half times the one-way fare, *provided* 150 certificates are deposited at the Convention headquarters. These certificates must be obtained when visitors purchase their one-way tickets to Swampscott. Members of families are also entitled to obtain certificates. After 150 certificates have been deposited and the certificates have been validated, return tickets over the same route may be purchased for half the usual rate. There are certain restrictions regarding purchase dates, travel dates, etc., and local ticket agents should be consulted in every case.

Everyone traveling by train to Swampscott should get a certificate whether he will use it or not. Failure to do so may deprive others of considerable saving.

Register in Advance

By registering in advance by mail, members will help the committees in making plans. Those who plan to attend may notify Institute headquarters, New York.

Committees

The 1929 Summer Convention Committee which is making the arrangements for the meeting consists of the following members who are officers of the committee or chairmen of other committees as indicated or general members: W. F. Dawson, *Chairman*; E. W. Davis, *Vice-Chairman*; H. B. Dwight, *Vice-Chairman*; C. S. Skoglund, *Vice-Chairman;* W. H. Colburn, *Secretary*; V. R. Holmgren, *Asst. Secretary*; F. L. Ball, *Treasurer*; H. P. Charlesworth, *Meetings and Papers*; W. B. Kouwenhoven, *Sections*; C. L. Edgar, *Finance*; C. A. Corney, *Trips*; F. S. Jones, *Transportation*; I. F. Kinnard, *Publicity*; W. E. Porter, *Hotel and Registration*; A. H. Sweetnam, *Sports*; Mrs. W. H. Timbie, *Ladies' Committee*; J. P. Alexander, G. J. Crowdes, W. S. Edsall, S. J. Eynon, J. W. Kidder, R. H. Porter, W. H. Pratt, Ernest Shorrock, D. F. Smalley, H. B. Wood.

Pacific Coast Convention

The 1929 Pacific Coast Convention will be held in Santa Monica, California, September 3-6. Plans are well under way for this meeting and details of the program will be published in the July and August Journals.

Regional Meeting in Chicago in December

A three-day regional meeting will be held under the auspices of the Great Lakes District in Chicago, December 2-4. A local committee has been working on plans for some time. Further information will be published in later issues of the Journal.

Japanese Ambassador Guest of Engineers

Katsuje Debuchi, Japanese Ambassador, was the honor guest at a dinner at the Carlton Hotel, Washington, D. C., Wednesday evening, April 24th, given by engineers, scientists, and industrialists who will represent the United States at the World Engineering Congress in Tokio next November. The occasion marked the last meeting of the American Committee on participation in the Congress, of which President Hoover is honorary chairman, prior to the departure of the delegation for Japan next October.

The Japanese Ambassador, John Hays Hammond and Gano Dunn, noted electrical engineers were the principal speakers, and stressed the importance of welding the forces of engi-

neering and science as an international factor for the promotion of comfort and prosperity in the world and the abolition of warfare.

Ambassador Debuchi said Japan is always ready to cooperate with the rest of the world in the advancement of learning and civilization and expressed the hope that the bond of mutual understanding that has existed between the United States and Japan will be cemented at the congress.

That the engineer will become an ambassador of good will was predicted by Mr. Hammond, who said that in the material development of civilization the engineer has always played an important role and in no period have his activities been more important than during the last few decades.

Mr. Dunn, who reviewed many of the brilliant achievements of Japan in the fields of science, medicine and other arts, pointed to the rapid development of engineering in Japan.

Chairman Elmer A. Sperry of the American Committee presided and the chairmen of various sub-committees made brief reports. About sixty members of the American Committee were present, including the following representatives of the A. I. E. E.: Messrs. A. W. Berresford, Gano Dunn, B. Gherardi, F. L. Hutchinson, Dugald C. Jackson, F. B. Jewett, C. O. Mailloux, O. C. Merrill, Robert A. Millikan, Farley Osgood, E. Wilbur Rice, Jr., Chas. F. Scott, Lewis B. Stillwell, S. W. Stratton and Ambrose Swasey.

The 1929 Lamme Medal

NOMINATIONS FOR THE 1929 AWARD WILL BE RECEIVED UNTIL SEPTEMBER 1

The Lamme Medal was founded as a result of a bequest of the late Benjamin G. Lamme, Chief Engineer of the Westinghouse Electric & Mfg. Company, who died July 8, 1924, to provide for the award by the Institute of a gold medal (together with bronze replica thereof) annually to a member of the A. I. E. E. "who has shown meritorious achievement in the development of electrical apparatus or machinery," and for the award of two such medals in some years if the accumulation from the funds warrants.

The first (1928) Lamme Medal has been awarded to Allan Bertram Field, Consulting Engineer, Metropolitan Vickers Electrical Company, Ltd., Manchester, England, "for the mathematical and experimental investigation of eddy current losses in large slot-wound conductors in electrical machinery," and will be presented during the Summer Convention at Swampscott, Mass., June 24-28.

Special attention is called to the fact that names of members of the Institute, who are considered suitable candidates for the Lamme Medal to be awarded in the Fall of 1929, may be submitted by any member in accordance with Section 1 of Article VI of the By-laws of the Lamme Medal Committee, which is quoted below:

"The Committee shall cause to be published in one or more issues of the A. I. E. E. JOURNAL each year, preferably including the June issue, a statement regarding the 'Lamme Medal' and an invitation for any member to present to the National Secretary of the Institute by September 1 the name of a member as a candidate for the Medal, accompanied by a statement of his 'meritorious achievement' and the names of at least three engineers of standing who are familiar with the achievement."

Each nomination should give concisely the specific grounds upon which the award is proposed, and also a complete detailed statement of the achievement of the nominee, which will enable the Committee to determine its significance as compared with those of other candidates. If the work of the nominee has been of a somewhat general character, in cooperation with others, specific information should be given regarding the contributions of the individual. Names of endorsers should be given as specified above.

STANDARDS

Test Codes for Electrical Machines

In the April JOURNAL mention was made of the proposed development of "Electrical Test Codes" and that a committee had been appointed to survey the situation. At the meeting of the Standards Committee May 8, the report of the special committee was made by its chairman, F. M. Farmer. The recommendations of the special committee, approved by the Standards Committee were, in brief, as follows:

1. That test codes for the more important classes of electrical apparatus; namely, generators, motors and transformers be prepared. Industry can thus be shown just what is contemplated and some idea of cost can be obtained.

2. That the scope of the tests be the prescription in detail of the procedure followed in making the various tests commonly required.

3. That the work be undertaken as an A. I. E. E. project under the direction of the Standards Committee, but that in view of the close contact of the Electrical Machinery Committee with the subject matter of the first proposed codes, they be prepared by that committee and reported to the Standards Committee.

Definition of Distortion Factor

At the February 27th meeting of the Standards Committee there was presented by the Instruments and Measurements Committee a proposed definition of distortion factor, as follows:

"Distortion factor of a periodic voltage or current wave is the ratio of the effective value of the residue, after the elimination of the fundamental, to the effective value of the original wave."

This definition was referred by the Standards Committee to the Electrical Machinery Committee for consideration.

Methods of Test for Determining Distortion Factor

Following the presentation of the suggested definition of distortion factor given above, the Instruments and Measurements Committee presented at the meeting of the Standards Committee of May 9th a progress report outlining in detail four methods of determining the distortion factor of the voltage wave of alternators. The methods described are as follows: (A) Method of Boucherot using an alternator with a sinusoidal wave and a voltmeter. (B) Method of Belfils using a bridge to suppress the fundamental and a voltmeter to read the residue. (C) From the Oscillogram. (D) By means of a harmonic analyzer. The Instruments and Measurements Committee is gathering further data on this subject, which it is hoped will show which of the various methods is preferable.

Measurement of Core Losses

At the meeting of the Standards Committee of May 9th a report dealing with the determination of the core losses of transformers was presented by the Instruments and Measurements Committee. It recommended that the following be incorporated in the Standards for Transformers, No. 13:

"The core loss of transformers shall be determined preferably with a sine wave of applied voltage; if this is not practicable, the results obtained with a distorted wave of applied voltage shall be corrected to a sine wave basis by a suitable method."

The committee then suggests that the available methods be given in detail and outlines three: The standard core method; the iron-loss voltmeter method; the flux voltmeter method.

The Standards Committee referred this report to the Electrical Machinery Committee for an opinion as to the exact form in which it should appear in the Transformer Standards.

Definitions of Breakdown Voltage and Dielectric Strength

About a year ago the Standards Committee appointed a special committee under the chairmanship of Doctor F. B. Silsbee of the Bureau of Standards to develop definitions for "breakdown voltage" and "dielectric strength." The committee reported at the May 9th meeting of the Standards Committee and the definitions suggested were accepted for reference to the subcommittee of the Standards Committee on Definitions and to a committee on Insulation of the National Research Council. The definitions suggested follow:

BREAKDOWN VOLTAGE

The breakdown voltage of an insulating structure is that minimum voltage, which when applied to a set of conductors separated by the structure causes a sudden disruptive discharge to take place.

In certain cases more specialized terms may be used to designate the breakdown voltage corresponding to particular conditions. Thus

1. The term "flashover voltage" is used in connection with line insulators or bushings to designate the breakdown voltage at which the discharge takes place through an air path around the insulator; while
2. the term "puncture voltage" is used to designate the voltage at which the discharge occurs through the insulating material. Also
3. the term "corona voltage" is used to designate the voltage required to initiate the partial breakdown of gaseous and liquid dielectrics, known as corona or brush discharge; while
4. the term "sparking voltage" is used to designate the equal or higher voltage at which the corona discharge changes to a spark.

The numerical value of the breakdown voltage which is obtained in any particular case will depend upon various factors such as the shape and size of the electrodes, kind, frequency, wave form and rate and time of application of voltage, temperature, atmospheric pressure and humidity, etc.

Values of breakdown voltage are expressed in terms of the crest voltage in the case of direct or of impulse voltage but in terms of effective sine-wave voltage in the case of alternating voltage of low or high-frequency.

ELECTRIC STRENGTH

The electric strength of a dielectric is that property by virtue of which the dielectric is able to withstand electric stress.

Electric strength is commonly expressed as the ratio of the breakdown voltage of the dielectric to its thickness; *e. g.*, volts per mil, volts per cm., kilovolts per mm.

Comparable values of electric strength for different materials can be obtained only from tests under identical conditions. Among these conditions are the shape, size and spacing of the electrodes, the frequency, wave form and rate and time of application of the voltage, the temperature, the atmospheric pressure, the humidity, etc., and the surrounding medium, (air or oil, for example).

When the dielectric is of such form that the average electric stress differs from the maximum electric stress within the dielectric, as for example, in electric cables, it is important to specify whether the average or the maximum value is being given.

Electric strength is also called "dielectric strength," "critical gradient," "disruptive gradient," etc.

Proposed Standards for Constant Current Transformers

At the May 9th meeting the Committee on Electrical Machinery presented to the Standards Committee a report in the form of proposed Standard for Constant Current Transformers. This proposed standard will be printed in report form and for purposes of criticism and suggestion will receive wide distribution before coming up for final adoption. Copies will be available within the next two weeks and may be obtained without charge by writing to H. E. Farrer, Secretary, Standards Committee, A. I. E. E. Headquarters.

Code for Protection Against Lightning Becomes American Standard

Under date of April 4, the American Standards Association approved parts I, II and III of the Code for Protection Against Lightning. Part I covers protection of persons and Part II protection of buildings and miscellaneous property. These was approved as American Standard, while Part III, on protection of structures containing inflammable liquids and gases, was approved as a Tentative American Standard. There are two additional parts of the code dealing with electric lines and apparatus still in process of development. While the A. I. E. E. and the Bureau of Standards are joint sponsors of this project, the code will be published and sold by the Government Printing Office, Washington, D. C.

AMERICAN ENGINEERING COUNCIL

ADMINISTRATIVE BOARD SPRING MEETING AT WASHINGTON, D. C.

Upon the call of President A. W. Berresford, the Administrative Board of American Engineering Council met in Washington, Friday and Saturday, May 24-25, preceded by an Executive Committee meeting on May 23 in the same place.

The meeting held in the Mayflower Hotel was the first meeting of the Administrative Board since the annual meeting in January, 1929. The Board is composed of the following members of American Engineering Council: A. W. Berresford, President; H. E. Howe, Treasurer; Vice-Presidents, L. P. Alford, O. H. Koch, I.E. Moultrop, G.S. Williams, Edwin F. Wendt, R. F. Schuchardt, M. M. Fowler, Col. J. H. Finney, H. A. Kidder, Farley Osgood, C. E. Skinner, William Boss, John L. Harrington, William S. Lee, R. C. Marshall Jr., Chas. Penrose, Elmer Sperry, D. R. Yarnall, W. F. Rittman, Edward Robinson, Burritt A. Parks, John S. Dodds, James R. Withrow, A. A. Krieger, H. A. Marshall; also three members of the American Society of Civil Engineers which has recently become a member of Council; *viz.*, A. J. Dyer, Vice-President A. S. C. E.; Frank Williams, Director 1928, and George T. Seabury, Secretary.

The chief matters of business to come before the Board were: Water Resources Legislation now being proposed by the various states and the extent to which, if any, council should participate in this movement; the distribution and use of the Report on Street Traffic Signs, Signals and Markings; the approval of the personnel of important committees; future flood control policy of Council; also a discussion of the program of Council for the next six months.

A. E. C. APPOINTS COMMITTEE ON DAMS

President A. W. Berresford has announced the appointment of the committee on legislation pertaining to the safety of dams, composed as follows: G.S. Williams, Ann Arbor, Mich., Chairman; L. F. Harza, Chicago, Ill.; Chas. G. Hyde, Univ. of Calif., W. P. Kreager, Vice-President and Chief Engr., Northern N. Y. Utilities Co., Trust Power Bldg., Watertown, N. Y.; W. S. Lee, Duke Power Co., Charlotte, N. C.

The integrity and professional qualifications of the members of this committee assure a report of distinct service to the American public and to all professional engineers whose duties bring them in contact with the construction of dams.

One of the first tasks of the committee will be to ascertain the facts connected with this problem. All the various methods of dealing with the question of the safety of dams will be analyzed and the most reasonable and practical solution to the problem

will be recommended to A. E. C. In order that those in positions of authority on this subject may avail themselves of its information this report, if approved by Council, will then be circulated widely.

Dallas Holds Outstanding Regional Meeting

An outstanding success among regional meetings of the Institute was the meeting held under the auspices of District No. 7 at the Adolphus Hotel, Dallas, Texas, May 7-9. The registered attendance of 541 is remarkable in a locality where travel distances are great, where the total membership of the District, which includes six states, is only 630 and the membership of the Dallas Section is only about 100. The interest of those attending was maintained throughout the meeting as indicated by the fact that the attendance at the technical sessions was never less than 325. At an address on the evening of May 7, there were 750 present, many of whom were not registered in the regular attendance records. One noteworthy feature was that about 200 members of Branches were present to take part in the Student division of the program.

The senior technical program consisted of fifteen papers presented in four sessions, the first session opening with an address of welcome by J. W. Carpenter, President of the Texas Power and Light Company. A summarized report on the discussion at these sessions will be published in the July JOURNAL and the complete discussion will be published with the respective papers in the TRANSACTIONS.

Two Student sessions were held and these are described more fully in the "Student Activities" section of this JOURNAL.

A most interesting lecture with many striking demonstrations was given on the evening of May 7. This lecture entitled *Science and Research in Telephone Development*, was presented by S. P. Grace of the Bell Telephone Laboratories, Inc. Of special interest were the demonstrations of "inverted" speech, delayed transmission of sound, and the artificial larynx.

Several inspection trips were taken to power stations, telephone plants, factories, and other places of engineering interest.

A dinner-dance on the evening of May 8 attended by more than three hundred and a luncheon with the Dallas Electric Club on May 7 were very pleasant features of the meeting.

Highest praise is due the local committees for their organizing ability and enthusiasm in creating exceptional interest in the meeting and for the effective manner in which all events were conducted.

The Regional Meeting Committee which had charge of the meeting was as follows: B. D. Hull, *Chairman, Vice-President South West District*; A. E. Allen, *Secretary, South West District*; L. T. Blaisdell, C. V. Bullen, B. J. George, W. C. Looney, G. A. Mills, C. P. Potter, G. C. Shaad, J. B. Thomas. The general Local Committee consisted of G. A. Mills *chairman*, A. Chetham-Strode, *secretary* and the chairmen of committees as follows: J. B. Thomas, *Meetings and Papers*; L. T. Blaisdell, *Entertainment and Reception*; W. C. Looney, *Transportation and Inspection*; E. L. Glander, *Hotels and Registration*; T. C. Rubling, *Attendance and Publicity*; C. G. Matthews, *Finance*; G. C. Shaad, *Student Activities*.

National Prizes Awarded for Papers

Four National Prizes for papers presented during 1928 have been awarded by the Committee on Award of Institute Prizes. These prizes consist of suitable certificates and $100 in cash, the cash prize being divided in case of joint authorship. These prizes will be presented to the winners on June 25 at the Summer Convention. The report of the Committee on Award is as follows:

The Committee on Award of Institute Prizes for the year 1928 has had a large number of very excellent papers from which to select the prize winners. In determining which of these should receive final consideration, the Committee has had the valuable assistance of the Chairmen of the various Technical Committees. In all, 107 papers were eligible under the Institute Rules for the First Prize. Nine were eligible for the Prize for Initial Paper and eight for the Prize for Branch paper.

In studying these papers, the procedure outlined in the Rules, adopted by the Board of Directors June 23, 1927, and revised as of December 7, 1928, and the rating plan contained therein, have been followed. As a result of its work, the Committee has awarded four National Prizes. Also five papers have been given honorable mention. The awards are as follows:

National First Prize in the field of Engineering Practise awarded to Philip Sporn for his paper entitled "Rationalization of Transmission-System Insulation Strength," presented at the District No. 1 Meeting, New Haven, Connecticut, May 9-12, 1928.

National First Prize in the field of Theory and Research awarded to Joseph Slepian for his paper entitled "Extinction of an A-C. Arc" presented at the Summer Convention, Denver, Colorado, June 25-29, 1928.

Honorable Mention in the field of Theory and Research awarded to:

Harry Nyquist for his paper entitled "Certain Topics in Telegraph Transmission Theory" presented at the Winter Convention, New York, February 13-17, 1928.

Robert E. Doherty and Clifford A. Nickle for their paper entitled "Synchronous Machines—IV" presented at the Winter Convention, New York, February 13-17, 1928.

Joseph T. Lusignan, Jr., for his paper entitled "A Study of High-Voltage Flashovers" presented at the District No. 4 Meeting, Atlanta, Georgia, October 29-31, 1928.

National Prize for Initial Paper awarded to Hubert H. Race for his paper entitled "Electric Conduction in Hard Rubber, Pyrex, Fused and Crystalline Quartz" presented at the District No. 1 Meeting, New Haven, Connecticut, May 9-12, 1928.

Honorable Mention for Initial Paper awarded to Ludwig Encke for his paper entitled "Interconnection of Power and Railroad Traction Systems by Means of Frequency Changers" presented at the District No. 1 Meeting, New Haven, Connecticut, May 9-12, 1928.

National Prize for Branch Paper awarded to Paul Klev, Jr., and D. W. Shirley, Jr. for their paper entitled "The Voltage-Ratio Characteristics of Audio-Frequency Transformers Determined by the Low-Voltage Cathode-Ray Oscillograph," presented at the joint meeting of the Oregon State College Branch and the Portland Section, May 25, 1928.

Honorable Mention for Branch Papers awarded to E. B. Torvik, A. A. Lundstrom and M. D. Pillars for their paper entitled "Electrical Characteristics of Neon Signs" presented at the joint meeting of the Oregon State College Branch and the Portland Section, May 25, 1928.

On account of the excellence of a large number of the papers it was quite difficult to make the final selections. This was particularly true in connection with the papers to be considered for the First Prize in the field of Theory and Research, in which there were many very high-grade papers. As indicated above, it was thought that three papers in this class were deserving of honorable mention. No prize was awarded for a paper in the field of Public Relations and Education.

Respectfully submitted,
(Signed) F. W. PEEK, JR.
(Signed) W. S. GORSUCH
(Signed) H. P. CHARLESWORTH, Chairman

A. I. E. E. Committee on Award of Institute Prizes

Districts Award Paper Prizes

Twelve Regional Prizes for papers presented during 1928 have been awarded by five Districts of the Institute. Each of these prizes consists of an appropriate certificate and $25 cash, the cash award being divided in case of joint authorship. The awards are as shown below.

DISTRICT NO. 1

Regional First Prize. C. F. Estwick for his paper entitled *Shunting of Track Circuits in a Polyphase System of Inductive Train Control*, presented at the New Haven Regional Meeting, May 9-12, 1928.

Regional Prize for Initial Paper. H. H. Race for his paper entitled *Electric Conduction in Hard Rubber, Pyrex, Fused and Crystalline Quartz*, presented at the New Haven Regional Meeting, May 9-12, 1928.

Regional Prize for Branch Paper. J. R. Burnett and S. R. Knapp for their paper entitled *Special Oscillograph Studies of Alternator Short Circuits*, presented at the Student Session of the New Haven Regional Meeting, May 9-12, 1928.

DISTRICT NO. 2

Regional First Prize and Regional Prize for Initial Paper. Lester L. Bosch, for his paper entitled *Development, Theory and Design of the Low-Voltage A-C. Network*, presented before a meeting of the Cincinnati Section on April 12, 1928.

Regional Prize for Branch Paper. D. T. Bell and A. M. Marzulli, for their paper entitled *Acoustic Shock and Hazard in Telephone Communication*, presented before a joint meeting of the University of Cincinnati Branch and the Cincinnati Section on May 10, 1928.

DISTRICT NO. 8

Regional First Prize. J. S. Carroll and Bradley Cozzens for their paper entitled *Sphere-Gap and Point-Gap Arc-Over Voltage as Determined by Direct Measurement*, presented at the Pacific Coast Convention, Spokane, Wash., August 28-31, 1928.

Regional Prize for Initial Paper. L. J. Turley for his paper entitled *Automatic Mercury Arc Power Rectifier Substation on the Los Angeles Railway*, presented at the Pacific Coast Convention, Spokane, Wash., August 28-31, 1928.

Regional Prize for Branch Paper. P. E. Warrington for his paper entitled *The Effect of Barriers in Insulating Oil*, presented at the Student Session of the Pacific Coast Convention, Spokane, Wash., August 28-31, 1928.

DISTRICT NO. 9

Regional Prize for Branch Paper. Paul Klev, Jr., and D. W. Shirley, Jr., for their paper entitled *The Voltage-Ratio Characteristics of Audio-Frequency Transformers Determined by the Low-Voltage Cathode-Ray Oscillograph*, presented at a joint meeting of the Oregon State College Branch and the Portland Section, May 25, 1928.

DISTRICT NO. 10

Regional First Prize. H. M. Lloyd for his paper entitled *Railway Motors*, presented at the Vancouver Section meeting May 1, 1928.

Regional Prize for Initial Paper. H. R. Sills for his paper entitled *Starting Characteristics of Synchronous Motors*, presented at the Toronto Section meeting March 9, 1928.

Plans for Power-Circuit Colloquium Now Complete

Final announcement with regard to the program for the summer colloquium on power-circuit analysis which is scheduled at the Massachusetts Institute of Technology June 10-22, 1929, has now been made by G. Dahl, Director of the Colloquium. The technical sessions will be conducted by means of lectures and round-table discussions by members of the Electrical Engineering staff and engineers invited from the industries, including manufacturing companies, operating companies, consulting engineers and those by whom the problem of power-system stability may be amply represented. Professors D. C. Jackson, V. Bush, and Director Dahl will be the speakers at the first technical session, opening the afternoon of Monday, June 10. Information regarding further sessions may be obtained by addressing the Director, G. Dahl, Department of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

Radio Commission Membership Confirmed

In February of this year, former President Coolidge recommended to the Senate for membership on the Federal Radio Commission, Arthur Batchelor of Massachusetts, and Prof. C. M. Jansky of Minnesota. The Senate, however, adjourned March 4 without confirming these appointments.

Upon the advent of President Hoover's administration, Gen. Chas. M. Saltzman and Wm. D. L. Starbuck, of Connecticut, were nominated for membership on the Radio Commission and these appointments have been confirmed by the Senate.

Both men have been identified with the field of radio engineering for a number of years, Gen. Saltzman through the Signal Corps of the U. S. A., and Mr. Starbuck, although receiving his early training as an engineer, is an attorney, and has devoted himself to the legal aspects of radio problems.

Welding Code for Building Construction

Code 1 Park A—Structural Steel, covering fusion welding and gas cutting in building construction has just been formally approved and issued by the American Welding Society. Parts B and C, relating to piping and tankage in buildings are being prepared.

This is the result of the increased use of welding and gas cutting in the construction and equipment of buildings. It has been brought to the attention of the American Welding Society with requests for assistance in the formulation of a revision to the resent existing Building Codes, or, if needs be, a set of new codes on the fabrication and erection of structural steel, piping, and tankage of buildings. In response to these requests, the Committee on Building Codes was appointed by F. T. Llewellyn, President of the American Welding Society, and the work of formulation has already progressed as reported in the first paragraph. This being the first edition of the Code, it has been made as simple as possible; the Committee, however, will gladly assist anyone in its interpretation if desired. Address communications to the American Welding Society, 33 West 39th St., New York, N. Y.

Changes in Federal Power Commission

The Federal Power Commission is composed of the Secretary of War, James W. Good; Secretary of Interior, Ray Lyman Wilbur, and Secretary of Agriculture, Arthur M. Hyde. President Hoover has designated Secretary of War Good as Chairman of the commission.

After serving for five years with the Federal Power Commission, Major Glen E. Edgerton has been ordered to the U. S. Military Academy to serve as an instructor of civil and military engineering. He is to be succeeded by Col. Max Tyler.

Prior to becoming chief engineer of the Commission, Major Edgerton occupied the office of Assistant Chief. He had previously served for two years as director of sales for the War Department, five years as Chief Engineer of the Alaskan Railroad Commission, and two years on the Panama Canal. He has served also as a member of the Board of Engineers for Rivers and Harbors. He will not assume new duties at West Point until August 24, 1929.

Grand Rapids Elects Engineer

The citizens of Grand Rapids, Michigan, recently elected Mr. Burritt A. Parks, member of the Assembly of American Engineering Council, and Chairman of the Peninsular Section of the A. S. M. E., a member of the City Commission. The group supporting Mr. Parks ran him under the slogan, "You Put an Engineer in the White House, Why Not One on the Commission."

Patton New Director U. S. Coast and Geodetic Survey

Following the death of Col. E. Lester Jones at his home in Washington on April 9, President Hoover has appointed Raymond F. Patton Director of the U. S. Coast and Geodetic Survey.

Progress on Survey of Land Grant Colleges

The Bureau of Education of the Department of Interior has announced extraordinary progress in the land grant college survey. The first questionnaire in this survey was distributed less than a year ago. Since then, 17 additional questionnaires ranging from 24 to 408 pages have been prepared and sent to 50 colleges attended by white students. Up to the present time, 516 of the questionnaires, or almost three-fourths of the total, have been returned to the Bureau completely filled out by the colleges.

The work of filling out the engineering questionnaire has been completed by almost two-thirds of the colleges. Forty of the Institutions have returned their copies to the bureau. The rapid progress made in the case of this questionnaire, it is stated, was due largely to the personality and energetic activity of Dean A. A. Potter, School of Engineering, Purdue Univ.

The data and items covered by this questionnaire avoid the field covered by the recent study of the Society for the Promotion of Engineering Education. The Bureau is now engaged in compiling and studying the data, and it is expected that within a comparatively short time some very constructive results will be forthcoming. Additional information concerning this survey may be obtained through the Bureau of Education, Department of Interior.

Engineer of Bureau of Public Roads Loaned to Colombia

Edwin W. James, Chief of the Division of Design of the Bureau of Public Roads, U. S. Department of Agriculture, has been appointed by the government of Colombia to serve as a member of a commission to study and prepare plans for the improvement of the entire system of transportation and communication in that country.

Mr. James has secured leave of absence of from three to six months to perform this work. He sailed from New York on March 21.

He has a wide knowledge of all phases of highway engineering problems, and his recent book entitled "Highway Construction, Administration and Finance" translated into Spanish, has enjoyed a wide circulation in Central and South America as well as in this country. He is also the author of numerous papers and technical treatises on highway engineering.

This appointment and method of handling it is considered highly appropriate, and is in conformity with the procedure recommended by American Engineering Council in such cases. In the last session of Congress, a bill, H. R. 7344, provided for the use of Bureau of Public Roads highway engineers in Latin-American countries but made provision for the payment of their salaries during such time by the U. S. Govt. This measure was opposed by American Engineering Council.

Boulder Engineers Named by Wilbur

Secretary Ray Lyman Wilbur of the Department of Interior, has announced the appointment of the following three outstanding engineers as consultants in the field service in the Bureau of Reclamation; Louis C. Hill, Colorado; Andrew J. Wiley, Idaho, and Wm. F. Durand, Cal.

These men will concern themselves particularly with the Boulder Canyon or Colorado River project. Mr. Hill was long in the service of the Bureau of Reclamation. Andrew J. Wiley has had a large experience in constructing irrigation systems, power plants and related works, and has a world reputation in the building of dams. Doctor Durand, for years Professor in the Engineering School at Stanford University, has participated in former studies of the Colorado River made by the Reclamation Service. In 1927 he was appointed a special adviser in the then proposed development of the lower Colorado River. His report was before Congress during the time that the legislation providing for the development of that region was being considered. He served on the President's Aircraft Board in 1925, and as a scientific attache of the American Embassy in London during the war.

Mr. Van Wagenen Appointed Boundary Commissioner

To fill the vacancy caused by the death of E. Lester Jones, James H. Van Wagenen, formerly Chief Engineer of the U. S. Section of the International Boundary Commission, has been appointed Commissioner of the International Boundary Commission for the United States. This Commission is charged with the responsibility of definitely locating the boundary between United States, Alaska, and Canada and the promotion of Mr. Van Wagenen to head the Commission with which he has been connected for so many years is viewed by the engineering profession as not only wise but well-earned. He is a member of the American Society of Civil Engineers and of the Washington Society of Engineers, has been active in American Engineering Council a sa member of the annual meeting committee, and was chairman of a special committee of Council to investigate methods of stabilizing business as part of the work of the Conference on Unemployment, called by Pres. Harding, Sept., 1921.

German Engineer on Lecture Tour

EUROPEAN AUTHORITY ON HYDRAULIC STRUCTURE EXPERIMENTATION VISITS AMERICA

Doctor Theodor Rehbock, an internationally known authority on hydraulics, arrived in America on March 16, and upon the invitation of Doctor S. W. Stratton delivered, at Massachusetts Institute of Technology, a series of lectures which terminated the second week in April. He then made a short trip into Canada, and, returning, lectured at University of Cornell, Detroit, and the University of Michigan. Arriving in Washington, D. C., April 20, he attended the annual meeting of the National Academy of Science, April 22, delivering a lecture on "The Use of Time Corrected Films in Hydraulic Experimentation."

On April 24, he was the honor guest at a dinner at the Cosmos Club given under the auspices of the Washington Society of Engineers.

Upon the invitation of Col. E. M. Markham, Commandant of the Ft. Humphreys School of Engineering for Army Officers, Doctor Rehbock was scheduled to deliver two illustrated lectures on the afternoons of April 25 and 26, but a slight indisposition caused a postponement of these lectures. He is now on a tour of inspection of the flood control works of the Mississippi River, and will visit Omaha, Kansas City, St. Louis, Memphis, and possibly New Orleans, returning to Washington May 5.

Mississippi Flood Control Opposition Grows

The Flood Control Act of 1928, under which the so-called Jadwin plan is being carried out by the Corps of Engineers, is less than a year old, but as the details of the project have become known, the inhabitants of the region have become more and more incensed and are demanding a reconsideration of the plan by an impartial and competent authority.

It is reported that the Army engineers fearing executive intervention are rushing into immediate construction the two most controversial features of the entire flood control plan, and have advertised the letting of construction contracts in the proposed Missouri floodway for May 22, with served notice that construction contracts on the Bouef floodway will be let on or about June 1. A non-partisan delegation from the Senate and House of Representatives has called upon President Hoover to discuss with him the Mississippi flood control situation and has been requested to prepare a written memorandum for his consideration setting forth its recommendations as to the executive action which he could and should take, and, the remedial legislation necessary to carry out the flood control act of 1928 as Congress had intended it to be carried out.

The report of the A. E. C. Flood Control Committee composed of Baxter L. Brown, John R. Freeman, Arthur E. Morgan, and Gardner S. Williams, was presented in January 1928, and there is nothing to indicate that the situation is any different today than a year ago.

Government Reorganization

Hon. Frederick W. Dallinger of Massachusetts introduced into the special session of Congress, April 18, a bill H. R. 1214, to authorize the President of the United States to reorganize the executive departments of the Government. The power given in the bill expires two years from date of passage.

A. I. E. E. Directors Meeting

The regular meeting of the Board of Directors of the American Institute of Electrical Engineers was held at Institute headquarters, New York, on Wednesday, May 22, 1929.

There were present: President R. F. Schuchardt, Chicago, Ill.; Past-President B. Gherardi, New York City; Vice-Presidents J. L. Beaver, Bethlehem, Pa.; A. B. Cooper, Toronto, Ont.; H. A. Kidder, New York City; Directors M. M. Fowler, Chicago, Ill.; C. E. Stephens, New York City; I. E. Moultrop, Boston, Mass.; H. C. Don Carlos, Toronto, Ont.; E. B. Meyer, Newark, N. J.; J. Allen Johnson, Niagara Falls, N. Y.; National Secretary Hutchinson, New York City. Present by invitation, Professor Harold B. Smith, Worcester, Mass., presidential nominee.

The minutes of the Directors' meeting of March 21, 1929, were approved as previously circulated.

The Board ratified the action of the Executive Committee, under date of April 8, 1929, on pending applications as follows: 143 Students enrolled; 189 Associates elected; 11 Members elected; two applicants transferred to the grade of Member; six applicants transferred to the grade of Fellow.

Appointment by the Executive Committee of Mr. Bancroft Gherardi as a Director of the American Standards Association was confirmed.

Reports of meetings of the Board of Examiners held April 3 and May 15, 1929 were presented. Upon the recommendation of the Board of Examiners, the following actions were taken: 183 Students were enrolled; 138 Associates were elected; 21 applicants were elected to the grade of Member; one applicant was elected to the grade of Fellow; 25 applicants were transferred to the grade of Member; six applicants were transferred to the grade of Fellow.

The Secretary reported 1462 members in arrears for dues for the year ending April 30, 1929, and was directed to transfer these members from the mailing list to a "suspended" list, and to employ the usual methods of collecting the dues and restoring the members to the active membership list.

Approval by the Finance Committee, for payment, of monthly bills amounting to $27,963.46, was ratified.

The annual report of the Board of Directors to the membership, for the fiscal year ending April 30, 1929, as prepared under the direction of the National Secretary, was considered and approved for presentation at the Annual Meeting of the Institute, on June 25.

The annual report of the National Treasurer for the fiscal year ending April 30, 1929, was received.

The annual reports of the general standing committees of the Institute (exclusive of the reports of the technical committees, which are presented at the Annual Summer Convention, in June), were presented, abstracts of which were incorporated in the Board of Directors' annual report.

The following were made "Members for Life" by exemption from future payment of dues, in accordance with Sec. 22 of the Constitution: Alton D. Adams, W. L. Bliss, L. S. Boggs, W. C. Burton, F. Elliot Cabot, H. B. Coho, Edward A. Colby, L. K. Comstock, F. J. Dommerque, W. L. R. Emmet, J. B. Entz, C. S. Hammatt, William R. Hewitt, H. M. Hobart, Thomas R. Rosenburgh, Frank J. Sprague, Henry C. Townsend, E. W. Trafford, P. V. R. Van Wyck, Charles H. Wilson.

A petition for the formation of a Section at Birmingham, Ala., was presented, and in accordance with the recommendation of the Sections Committee, the petition was granted.

Upon the recommendation of the Committee on Student Branches, authorization was given for the establishment of Student Branches at North Dakota Agricultural College, Southern Methodist University, and University of New Mexico.

In accordance with Sec. 37 of the Constitution, the appointment of a National Secretary for the administrative year beginning August 1, 1929, was considered, and National Secretary F. L. Hutchinson was reappointed.

Upon the recommendation of the Standards Committee, approval was given to the discharge of the Sectional Committee on Rating of Electrical Machinery; a revision of the Standards for Hydraulic Symbols was approved, and approval given to the preparation of electrical tests codes for the important classes of electrical apparatus; namely, generators, motors, and transformers.

The President was authorized to appoint delegates of the Institute to the International Conference on Large Electric High-Voltage Systems to be held in Paris, June 6-15.

Other matters were discussed, reference to which may be found in this and future issues of the JOURNAL.

Book Reviews

HANDBOOK OF REFRIGERATING ENGINEERING. By W. R. Woolrich, M. E. D. Van Nostrand Company, Inc., New York, N. Y., 332 pp., 5 x 7 in., flexible cloth, illustrated, 1929. Price $4.00.

This book comprises a very complete compilation of data on refrigeration which has recently come into such common use that a study of its general principles and the apparatus employed becomes of importance. The work has been designed for the instruction of constructing and operating engineers and for students in engineering colleges, and has been developed as a series of lectures: It contains 19 sections on various phases of refrigeration and a supplementary section of miscellaneous tables. Each section concludes with a series of practical problems and questions by means of which the student can test his knowledge of the subjects covered. The treatment is brief and concise, and the book contains sufficient information to solve almost any practical problem in refrigeration.

HOW TO WIND DIRECT-CURRENT ARMATURES. By W. E. Hennig. The Bruce Publishing Company, Milwaukee, Wisconsin. Second edition, revised, 206 pp., 7 x 10¼ in. cloth, illustrated, 1928. Price $3.00.

The author presents in a very clear and practical manner the numerous types of d-c. armature windings with diagrams and explanations which a student who has had no engineering training can understand. The book is addressed to the practical armature winder and home student rather than the technically educated engineer, as it contains but little mathematics and theory, and is not a treatise on the principles and design of d-c. machines. It, however, explains and illustrates practically all of the d-c. winding diagrams in general use and in addition contains useful information on armature testing, adapting machines to changed conditions, and numerous examples of rewinding for voltage changes. The author's experience both as a teacher and a commercial engineer has enabled him to produce a work in accord with the latest commercial and manufacturing practises.

THE ELECTRICAL CONDUCTIVITY OF THE ATMOSPHERE AND ITS CAUSES. By Victor F. Hess. Translated from the German by L. W. Codd. D. Van Nostrand Company, Inc., New York, N. Y., 5¾ by 8⅞ inches, 204 pp., cloth, illustrated, 1928. Price $4.00.

The rapid advances in the knowledge of the conduction of electricity in the atmosphere which has taken place in recent years has been available only in articles scattered through technical periodicals. The book by Dr. Hess offers a very complete treatise on atmospheric ionization under a single cover, which has been revised during the course of translation to include the progress in this field down to January, 1928. The general explanation of electrical conductivity in the atmosphere is followed by a study of gas ions and the sources of ionization. The concluding chapters treat of the processes which operate to destroy ions, and the ionization balance of the atmosphere. The work of the numerous investigators in this field is reviewed and a bibliography on atmospheric electricity and collateral researches is included. The book is addressed primarily to scientists but it includes fundamental theory and results which will appeal to the general reader.

THE RADIO MANUAL. By George E. Sterling. Edited by Robert S. Kruse. D. Van Nostrand Company, Inc., New York, N. Y., 5¾ by 8 inches, 666 pp., cloth, illustrated, 1929. Price $6.00.

This is a comprehensive handbook on the general theory and practise of radio, and covers the subject so fully that it will be found useful to anyone interested in the subject, whether expert or amateur. There are several chapters devoted to the elements of electricity and magnetism leading up to the theory of radio, followed by detailed descriptions of numerous transmitting and receiving sets with their circuit diagrams. There are also descriptions and circuit diagrams of commercial and broadcast apparatus as used on board ships and in land stations, with instructions for maintenance, operation, finding defective parts, and making necessary repairs and replacements. Radio laws of the United States and the International Telegraphic Conference are given and a chapter is devoted to handling and abstracting traffic. Sufficient information is given to enable the student to secure a commercial or broadcast license or to pass the U. S. Civil Service examinations for radio inspectors and engineers in Federal service.

ELEMENTS OF PRACTICAL MECHANICS. By Charles R. MacInnes. D. Van Nostrand Company, Inc., New York, N. Y., 6¼ x 9¼ inches, 130 pp., cloth, illustrated, 1929. Price $2.25.

The book is the outcome of the author's classroom experience and it is intended for use especially with classes of engineering students. Its use presupposed a knowledge of calculus and physics. The treatment takes up in turn coplanar and non-coplanar forces, center of gravity, rectilinear and curvilinear motion, work, energy, power, moment of inertia, motion, impact, momentum, and cases involving friction. Graphical methods are developed in parallel with the analytical methods, and illustrative examples are freely used. Numerous problems are included with each chapter, to which answers are given.

SPEECH AND HEARING. By Harvey Fletcher. D. Van Nostrand Company, Inc., New York, N. Y., 6¼ by 9¼ inches, 330 pp., cloth, illustrated, 1929. Price $5.50.

The results of work in the Bell Research Laboratory are embodied in this volume. Some fifteen years ago an investigation of the constitution of speech and hearing was planned with the object of analyzing every part of the system from the voice through the telephone instruments to and including the ear. During the progress of this research a number of new instruments and devices has resulted which have found other important uses, such as providing means of speech for some whose vocal chords are gone, and means of accurately measuring the sense of hearing. The primary object of this research, which is yet far from finished, was to determine the requirements and limitations of transmission of speech in the telephone system, and with the facts of this investigation established, the effect of contemplated changes or developments can be more readily evaluated.

The book is divided into four parts: (1) Speech, (2) Music and Noise, (3) Hearing, (4) Perception of Speech and Hearing. Part I describes the mechanism of speaking, characteristics of speech waves, speech power, and frequency of occurrence of different sounds. Part II gives similar information in regard to music and noise. Part III deals with the mechanism of hearing, limits of audition, minimum perceptible differences in sound, masking effect of different pitched sounds, binaural effects, and a description of apparatus used in determining these values. Part IV treats of loudness of sound, recognition of pitch and those features which involve personal judgment. Methods of measurements and experimental results are given of types of sound distortion and the ability of persons to recognize them. The book well illustrates the value of systematic research which, though much remains to be completed, has yielded valuable results in its special field as well as in entirely unforeseen directions.

PERSONAL MENTION

H. CALVERT, of Calvert and Barnes, Designing and Consulting Engineers, Philadelphia, announces a change of address to the twelfth floor of the Crozer Building, 1420 Chestnut Street.

C. H. MAYER has resigned from his position in the Works Department of the Westinghouse Lamp Company, Bloomfield, N. J., to become Electrical Engineer of the Ce Co Manufacturing Company of Providence, R. I.

E. H. BOLLENBACHER, who was connected with the firm of McClellan & Junkersfeld, Inc., New York, for the past six years, has opened an office in Atlanta, Ga., as Manufacturers' Representative on Sales Power Plant Equipment.

H. P. DAVIS, Vice-President, formerly in charge of Westinghouse manufacturing operations, will now devote his entire time to the company's radio activities. He will report to Mr. A. W. Robertson, Chairman of the Board of Directors.

HERBERT C. MOYER, who for the past five years has served as Meter Engineer of the Standardizing Laboratory of the Pennsylvania Power & Light Company, has resigned and accepted a position as Assistant Chief Engineer of the U. S. Gauge Company, Sellersville, Pa.

H. W. YOUNG, President of the Delta-Star Electric Company, Chicago, Illinois, sailed June 1 on the Majestic and will visit the Delta-Star European connections. He will also present a paper on Outdoor Substations at the International High-Tension Conference to be held in Paris, June 6 to 15.

THOMAS C. CLARK, formerly District Manager of the St. Louis territory for W. N. Matthews Corporation, St. Louis, has been made sales manager of the company. Mr. Clark was Superintendent of the Central Division of the Union Light & Power Company previous to his affiliation with the W. N. Matthews Corporation.

W. J. S. Dormer, previously on the staff of the District Engineer of the Bell Telephone Company of Canada, at Quebec City, as Assistant Field Engineer, has accepted a position as Toll Line Engineer, Eastern District of the Bell Telephone Company of Canada, with headquarters at Montreal, in charge of toll line reconstruction and the building of new toll lines.

Colin B. Kennedy, one of America's oldest radio manufacturers, has organized a new company to be known as the Colin B. Kennedy Corporation, South Bend, Ind. It is expected that a thousand people will be employed by this new organization which anticipates production of over 1000 sets per day. Mr. Kennedy will be its President.

F. J. Bullivant, who for the past several years has had extensive electrical and radio experience and has done much in the development and application of rectifiers, will have full charge of the Sales Department of the B-L Electric Manufacturing Co., St. Louis, Mo., a new company formed from The Benwood-Linze Co.

Doctor Charles C. Lauritsen, formerly Chief Engineer of the Kennedy Company, will continue in like capacity with the newly formed company in charge of the Engineering Department. For the past two years he has been engaged in research at the California Institute of Technology, where his work in connection with X-ray experimentation has been of great interest to the scientific world.

David B. Rushmore, a retired engineer of New York City and Fellow of the Institute since 1913, has been appointed by President Hoover to represent the United States at the meeting of the World Power Conference in Barcelona, Spain, this month. Mr. Rushmore has represented this country at previous meetings of the conference. The subject of complete utilization of water power will be taken up at the meeting.

John B. Klumpp, after 35 years of continuous service with the United Gas Improvement Company, has resigned from the vice-presidency of that company to become a utility consultant, with offices in Philadelphia. From 1904 to 1919 Mr. Klumpp made examinations and reported on all utility properties, both gas and electric, for the United Gas Improvement Company. He was later made Assistant General Manager, and for the past five years has been a Vice-President.

John C. Clendenin formerly associated with the Automotive Engineering Department of the General Electric Co., has accepted a position as Sales Engineer with the Ward Motor Vehicel Company, Mount Vernon, N. Y. Mr. Clendenin has spent many years in the design, manufacture and application of electrical equipment for use on battery-driven and gasoline-electric vehicles, and in his new position he will continue to serve the industry in a capacity to which he has been fitted by long experience.

Obituary

Ferdinand Voelker, Jr., a member of the Technical Staff of the Bell Telephone Laboratories, died May 12, following an operation in the Rahway General Hospital, Rahway, N. J.

Mr. Voelker was born in New York City July 11, 1902 and after four years in general High School work and three years in technical training courses in engineering arranged by the Western Electric Company, he remained with that company from February 1920 to December 1924 doing drafting and test work. Upon January 1, 1925 he joined the Bell Telephone Laboratories, Inc., where his work was that of Telephone Equipment Engineer, working on current telephone equipment development.

Mr. Voelker joined the Institute in 1927 as an Associate.

Edmund Perkins Edwards, manager of the Radio Department of the General Electric Company since its organization in 1921, died at his home in Schenectady on April 27, following an illness of nearly a year. Graduated from Rose Polytechnic Institute in 1899 with the degree of Bachelor of Science in electrical engineering, he entered the employ of the General Electric Company in the same year.

In 1906 he went with the Lighting Department, becoming Assistant Manager of the department after a time. He was active in the early commercial activities regarding radio apparatus and in 1921, when the Radio Department was organized, he became Manager of the department, in charge of commercial, engineering and manufacturing activities.

Mr. Edwards was commissioned in May, 1922, as a lieutenant-colonel in the Signal Officers' Reserve Corps, and was assigned to the war-time procurement office of the chief signal officer. He was a member of numerous engineering and technical associations, and became a member of the Institute in 1925.

Clarence G. Hadley, Superintendent of the Franklin Heating Station, Rochester, Minn., and an Associate of the Institute (1910), died the early part of May last. He was born at Mumford, New York, January 25, 1884; in 1902 he was graduated from the Friends Boarding School at Westtown, Pa., and in 1907, from Cornell University with an M. E. degree. During 1900 he worked as a telegrapher, and other summer vacations were spent in the employ of the Baltimore, Reading, and Pennsylvania Railroad and the Baltimore and Ohio Railroad Company. After finishing at Cornell, the next two and a half years were given to departmental test work for the General Electric Company. He was Assistant Foreman of the Turbine Test Department at the time of his leaving that company in 1910 to become Electrical Engineer of the Fessenden Wireless System for the National Electric Signaling Company at Brant Rock, Mass. In 1925 he removed to Rochester, Minn., where he was chosen first superintendent of the Municipal Electric Properties, later to become Manager of the Central Heating and Power Plant, designed by Ellerbe & Company, St. Paul. This plant supplied water, light, heat, and power to the Mayo Clinic in that City. In 1927 he was made Manager of the Franklin Heating Station, the position he last occupied.

William Eugene Keily, Associate 1904, died April 23, 1929, at his home in the Webster Hotel, Chicago, after an illness of only three days with angina pectoris.

For years Mr. Keily was western editor of the *Electrical World*, but had more recently been engaged in special work for Mr. Samuel Insull. He was born at Utica, New York, June 4, 1865, and after an academic education, public schools and high school at Syracuse, he became interested in journalistic work, taking his first position as Associate Editor of the *Western Electrician* March 1, 1891 and promoted to the managing editorship July 15, 1899. Throughout his entire career he was devoted to literary and consulting work connected with public utility problems and relationships. In 1908 the *Western Electrician* was sold and Mr. Keily resigned. For a short period he did free lance work, but early in 1909 he became Western Editor for the *Electrical World*, the position which he retained until 1915. Conspicuous among his editing accomplishments is his work on Mr. Insull's books, "Central Station Electric Service" and "Public Utilities in Modern Life." He held membership in the Western Society of Engineers, the American Association for the Advancement of Science, the Illuminating Engineering Society and other similar professional bodies.

Henry W. Blake, who joined the Institute as an Associate in 1888 and was made a Member in 1913, died May 20 at his home in Englewood, N. J. A pioneer in the field of business journalism devoted to street railways, Mr. Blake, at the time of his death, was senior editor of the *Electric Railway Journal*, the editorial staff of which he joined in 1891 when it was the *Street Railway Journal*, a publication devoted to horse-car transportation; in 1894 he became its Editor-in-Chief, and when in 1908 it changed its name to the *Electric Railway Journal*, Mr. Blake assumed his new editorial duties, continuing without interruption until his death.

Born in New Haven, Connecticut, December 7, 1865, the son of Henry Taylor Blake, a noted member of the Connecticut bar, he graduated a civil engineer from Yale University in 1886, after

which he studied electrical engineering at Massachusetts Institute of Technology. Following this course, he did advertising work for the Sprague Electric Railway and Motor Company, an organization engaged in the construction of electric railways in various cities throughout the United States. This is the organization which he left to joint the staff of the *Street Railway Journal*. In 1927, Mr. Blake took an extended editorial tour abroad, for the purpose of specific study of the street railway transportation systems in Europe, visiting Naples, Rome, Florence, Milan, Nice, Paris, Brussels, Berlin, Hamburg and London.

He was always active in the affairs of the American Electric Railway Association and was a regular attendant at its annual meetings. Mr. James H. McGraw, with whom Mr. Blake was continually associated during his 35 years of service on the *Electric Railway Journal*, said of him "He was a great editor. His name will go down in the history of industrial journalism with those of Col. Henry G. Prout of the Railway Gazette, W. D. Weaver of the *Electrical World*, Arthur M. Wellington of the *Engineering News*, Charles Kirkchoff of *Iron Age*, John M. Godell of *Engineering Record* and Frank Wright of *Engineering News-Record*." In addition to his membership in the American Electrical Railway Association, he was a member of the Engineers Club of New York, the Englewood Club and the Knickbocker Country Club of Tenefly. He was also an Associate member of the Union Internationale de Tramways et de Chemins de Fer d'Interet local of Brussels.

Fred C. Hamer, Electrical Engineer, Sargent & Lundy, Inc. and since 1919 an Associate of the Institute, died early in May in Chicago, his native city, where, since 1909, he has pursued his professional activities. After a two years' correspondence course in mechanical drafting, one year in the Chicago Technical College, and three years at Armour Institute of Technology, completing his course in electrical engineering, Mr. Hamer spent ten years in drafting, designing and inspection work. During 1909 he was employed by Franklin J. Cary, M. E. in machine design work; then he joined the Commonwealth Edison Company remaining two years in its Transmission and Distribution Departments, on record and drafting work. From 1912 to 1917, Mr. Hamer was with the Electrical Department of the Sanitary District of Chicago, doing work on inspection and design of line construction and substation construction, street lighting and power work. In 1918 he entered the employ of Sargent & Lundy, Inc., where his first year's work was on power plant design. As an applicant for membership in the Institute, Mr. Hamer received the hearty endorsement of all asked to give the customary personal references, both with regard to his professional ability and his own characteristics.

A. I. E. E. Section Activities

FUTURE SECTION MEETINGS

St. Louis

June 19.

Sharon

Communism, by Capt. J. Robert O'Brien. Banquet meeting. June 4.

NEW YORK SECTION ELECTS OFFICERS FOR 1929-30

At the meeting of the New York Section of April 26th the announcement of the election of officers of the New York Section for 1929-30 was made. The Executive Committee of five men will take office August 1st as follows:

Chairman:	H. P. Charlesworth, Vice-President, Bell Telephone Laboratories,
Secretary-Treasurer:	T. F. Barton, District Engineer, General Electric Co.
Executive Committee:	E. E. Dorting, Lighting Engineer, I. R,
	T. Henry Flood, Consulting Engineer. Murray & Flood,
Junior Past Chairman:	R. H. Tapscott, Electrical Engineer, New York Edison.

COMMUNICATION GROUP OF NEW YORK SECTION ORGANIZED

On Friday evening May 17, the newly formed Communication Group of the New York Section held its first meeting. Through the courtesy of the New York Telephone Company the meeting was held in the auditorium of the New York Telephone Building, 140 West St., New York at 7:30 p. m. Following a brief talk by Chairman R.H. Tapscott of the Section on the "Group Idea" and an election of temporary officers of the Communication Group to hold office until August 1, 1930, there were two papers presented as follows: "Some Telegraph Traffic Engineering Problems," by C. M. Brentlinger and I. S. Coggeshall, General Traffic Supervisors, Western Union Telegraph Company; "Handling Telephone Traffic In and Around New York City," by J. P. Andrews, General Traffic Engineer, Long Island Area, New York Telephone Company. After the presentation of the second paper the meeting was opened to general discussion.

Preceding the meeting a very excellent cafeteria supper was served for a nominal figure in the cafeteria on Floor B of the telephone Building. The large lounge room adjoining the restaurant was opened to accommodate those attending the meeting. About 200 members and guests of the Section took advantage of the supper accommodations and later on over 300 attended the meeting.

NORTH CAROLINA SECTION ORGANIZED

The formation of a North Carolina Section of the Institute was authorized by the Board of Directors on March 21, 1929. The organization meeting held in Charlotte on May 2 was attended by twenty-one petitioners. An address of welcome to the visiting members was delivered by Mr. C. O. Kuester, Secretary and Business Manager of the Charlotte Chamber of Commerce.

The following officers of the Section were elected: Chairman, E. P. Coles; Secretary and Treasurer, M. E. Lake; Executive Committee, P. H. Daggett, J. H. Paget and J. H. Roddey. Mr. Coles took charge of the meeting immediately after the election and invited the members to discuss methods by which the Section might most effectively proceed, in order to contribute a definite service to both its members and the Institute. An interesting and helpful discussion followed.

JOINT SECTION AND BRANCH MEETING AT UNIVERSITY OF IDAHO

A joint meeting of the Spokane Section and the Student Branches of the State College of Washington and the University of Idaho was held at the latter University on April 26, with an attendance of 47. Following a dinner, entertainment was supplied by the University of Idaho quartet. Brief addresses were given by Bernhard Olsen, Chairman, Spokane Section, Dean H. V. Carpenter of State College of Washington, and Professor J. H. Johnson, Counselor, University of Idaho Branch. Orland Mayer, Chairman of University of Idaho Branch, presided. The principal paper of the evening was entitled "Power Limit of Synchronous Machines and Its Influence on System Design" by Richard McKay, Assistant Electrical Engineer, Washington

Water Power Company, and N. P. Bailey, Assistant Professor of Mechanical Engineering, University of Idaho.

INSTITUTE AFFAIRS DISCUSSED BY WASHINGTON SECTION

A dinner meeting of the Washington Section held on April 24 was devoted to a discussion of various phases of the subject "Institute Affairs and Their Relation to Our Section and Community." Brief addresses were given by the following: Hon. Proctor L. Dougherty, Commissioner of the District of Columbia; Maj. W. A. Danielson, Quartermaster Corps, U. S. Army; Dr. M. G. Lloyd, Senior Electrical Engineer, Bureau of Standards; Capt. A. F. E. Horn, Local Manager, General Electric Co.; E. C. Crittenden, Chief, Electrical Division, Bureau of Standards; J. A. Ferry, Electrical Engineer, Potomac Electric Power Co.; C. A. Robinson, Chief Engineer, Chesapeake and Potomac Telephone Co.; H. H. Henline, Assistant National Secretary; Prof. J. L. Beaver, Vice-President, Middle Eastern District, A. I. E. E., and President R. F. Schuchardt.

Some of the topics particularly emphasized by various speakers were the duties of engineers as citizens, the importance of interpreting engineering to the public, benefits received by individuals from participation in Institute activities, methods by which the interest of members may be increased, and the need for cooperation in the advancement of the profession. President Schuchardt spoke briefly upon these topics and others, and mentioned his efforts during the present year to encourage the Sections to study themselves in order to determine whether they are living up to their magnificent opportunities.

CONTACTS BETWEEN ENGINEERS AND PUBLIC DISCUSSED BY LOUISVILLE SECTION

The meeting of the Louisville Section held on April 11 was devoted to a discussion of the subject "The Desirability of Developing Closer Contacts Between Engineers and the General Public." The principal papers presented were: Mr. Public and Mr. Engineer Must Meet," by Robert E. Tafel, Nachod and United States Signal Co., and "The Relation of the Electrical Engineer to the Public," by Professor D. C. Jackson, Jr., University of Louisville. A discussion of these papers was presented by George W. Hubley, Consulting and Advisory Engineer.

SECTION ACTIVITIES DISCUSSED IN SCHENECTADY

At the dinner meeting of the Schenectady Section held on April 9, 1929, the following addresses were given on the general subject "Service Through the Institute Section:"

As Viewed by a Past-President, C. C. Chesney, Vice-President, General Electric Co.

As Viewed by a Member, L. T. Robinson, General Engineering Laboratory, General Electric Co.

As Viewed by the President, R. F. Schuchardt.

E. S. Lee, Chairman, reviewed the activities of the Section during the past year.

As a direct result of the meeting, the Executive Committee of the Section is considering means by which it can take an active interest in civic affairs. The attendance was 175, and the informal nature of the meeting promoted general discussion and acquaintanceship.

JOINT SECTION AND BRANCH MEETING IN COLUMBUS

The annual joint meeting of the Columbus Section and Ohio State University Branch was held at the University on May 3. After a dinner at the Ohio Union, the present officers, a number of past officers, and other members of the Columbus Section were called upon for brief remarks. Professor F. C. Caldwell, first Chairman of the Section, and all other Past Chairmen, except one, were present.

The evening session was opened by a two-reel motion picture on electric welding. This was followed by a talk on the subject "Progress after Graduation" by R. E. Knox, a senior in electrical engineering. A. G. Gibbony of the Ohio Power Company gave a brief address. A talk, entitled "Branch Activities," was given by H. H. Henline, Assistant National Secretary. The attendance was about 45.

JOINT SECTION AND BRANCH MEETING IN SEATTLE

The annual joint meeting of the Seattle Section and the University of Washington Branch for the presentation of a student program was held on April 16. After a brief business session of the Section, over which C. R. Wallis, Chairman, presided, the meeting was turned over to C. W. Huffine, Chairman, University of Washington Branch, and the following papers were presented by students:

Energy Losses by Radiation from Domestic Hot Water Tanks, R. P. Wailes.

Voltage Amplification of the Screen Grid Tube as an Intermediate Frequency Amplifier, by Frank Giovanini, presented by Kenneth M. Durkee.

Students of the University of Washington supplied music before and after the technical program. The attendance was 150.

JOINT SECTION AND STUDENT MEETING IN URBANA

The Urbana Section, the Electrical Engineering Society of the University of Illinois, and the Student Branches of Purdue University and Rose Polytechnic Institute held a joint meeting at the University of Illinois on April 20, for a discussion of the subject "Electrical Society Activities of Undergraduate Students." The total attendance of 140 included 30 from Purdue and 18 from Rose Polytechnic Institute.

Addresses were given by representatives of the three student organizations as follows: B. D. Landes, Purdue University, H. A. Moench, Rose Polytechnic Institute, and Herbert Levy, University of Illinois. Each reported upon the principal activities of his organization. President R. F. Schuchardt emphasized the need of engineers for appreciation of other fields of activity and offered suggestions for student participation in programs. A luncheon was served after the program.

JOINT SECTION AND BRANCH MEETING IN NEBRASKA

The Nebraska Sections of the Institute and the A. S. M. E. gave a complimentary dinner to the enrolled Students of the two societies in the University of Nebraska and the University of South Dakota, in Omaha, on April 17. C. D. Robison, Chairman of the Nebraska Section, A. I. E. E., presided over the business meeting, and L. E. Shoemaker, Electrical Engineering '29, of the University of Nebraska, served as toastmaster during the program.

Professor B. B. Brackett, Counselor, University of South Dakota Branch, Dean O. J. Ferguson, University of Nebraska, Vice-President, North Central District, A. I. E. E., and E. Johnson, Chairman, University of South Dakota Branch gave brief addresses. The following papers were given by students:

Diesel Engines for Aeroplanes, C. W. Sharp, Mechanical Engineering '30, University of Nebraska.

Telephone Rates, P. F. Fink, Electrical Engineering '29, University of Nebraska.

Music was furnished at various times during the program by students of the two Universities. The attendance was 98.

JOINT SECTION AND BRANCH MEETING IN AKRON

The Akron Section and University of Akron Branch held a joint meeting on April 25. John C. Schacht, Chairman of the Papers and Meetings Committee of the Branch, presided during the presentation of the following papers by students:

Interesting Facts on Radio, H. Shively.

Our "Co-op" System, P. Bierman and L. Rang.

Development of Photoradiogram Service, T. Starr.

Westinghouse Portable Oscillograph, W. Wilson.

After the completion of the technical program, the following laboratory demonstrations were given by students: Westinghouse portable oscillograph, W. Wilson and W. Woodward; cathode ray oscillograph, E. Hartman; high-frequency apparatus in operation, P. Bierman; paralleling of alternators, G. Hite and W. Hoffman; phase advancer test, L. Rang and T. Starr.

The meeting was considered very successful. The attendance was 50, of whom about one-half were members of the Section.

PAST SECTION MEETINGS

Akron

Joint meeting with University of Akron Branch. See report in Student Activities dept. April 25.

Boston

Some Aspects of Railway Electrification, by B. S. Cooper, Westinghouse Electric & Mfg. Co. Slides. April 2. Attendance 120.

Chicago

Iron and Steel Melting in the Electric Furnace, by D. T. Waby. The following officers were elected: Chairman, T. G. LeClair; Vice-Chairman, F. H. Lane; Secretary-Treasurer, L. S. Leavitt; Executive Committee, P. B. Juhnke, W. O. Kurtz and E. H. Freeman. Joint meeting with Western Society of Engineers, Electrical Section, preceded by a dinner for the speaker and the Executive Committee. April 22. Attendance 130.

Cleveland

The Electric Eye, by P. B. Findley, Managing Editor, Bell Laboratories Record. A number of other engineering societies in Cleveland were invited to attend this meeting. April 18. Attendance 1250.

Columbus

Outdoor Lighting, by S. E. Strunk, Engg. Dept., National Lamp Works, General Electric Co. Illustrated. October 26. Attendance 22.

Electric Welding of Steel Building and Bridges, by F. P. McKibben, Consulting Engr., General Electric Co. (Illustrated). November 23. Attendance 75.

Television, by Dirk Schregardus, Transmission Engr., The Ohio Bell Telephone Co. Illustrated. January 4. Attendance 130.

Discussion of the following subjects: Continued membership in the Affiliated Technical Society of Columbus; Programs for the remainder of the year; Means for increasing membership; The Section's attitude toward membership in a general engineering society. Film, "Driving the Longest Railroad Tunnel in the Western Hemisphere." March 1. Attendance 15.

Tour of Oil Fields of Europe, by A. E. Dralle, Westinghouse Electric & Mfg. Co. Illustrated. Joint with Columbus Engineers' Club. March 29. Attendance 60.

Connecticut

Science and Research in Telephone Development, by S. P. Grace, Asst. Vice-President, Bell Telephone Laboratories, Inc. Joint with Yale University Branch, in New Haven. April 23. Attendance 2500.

Dallas

Static and Transient Stability of Interconnected Power Systems, by P. H. Robinson. Transmission Engr., Houston Lighting & Power Co. Nominating Committee appointed. Reports received from Regional Meeting Committees. April 15. Attendance 65.

Denver

Luncheon meeting of Colorado Engineering Council handled by Denver Section. W. G. Baldry and Miss Eleanor Fish gave a demonstration of the operation of the dial telephone. April 2. Attendance 45.

Recent Developments of Electrical Research, by C. E. Skinner, Asst. Director of Engg., Westinghouse Electric & Mfg. Co. Demonstrations. W. H. Bullock, Chairman, Program Committee, reported on future meetings. The meeting was preceded by a dinner. April 12. Attendance 60.

Annual College Branch Night. See report in Student Activities dept. April 26.

Detroit-Ann Arbor

Protective Relays and Their Application, by T. R. Hallman, Detroit Edison Co., and J. R. North, Stevens and Wood, Inc. Business session. A dinner preceded the meeting. April 16. Attendance 175.

Erie

Making Sound Visible and Light Audible, by J. B. Taylor, Consulting Engr., General Electric Co. April 19. Attendance 250.

Fort Wayne

Recent Developments in Aviation, by Major W. A. Bevan, Air Corps Reserve, Associate Professor of Aeronatuical Engg., Purdue University. Motion pictures before meeting and refreshments after. April 18. Attendance 100.

Houston

Power Factor—Its Improvement and Relation to Rates, by J. C. Coates, Houston Lighting & Power Co. A dinner preceded the meeting. April 24. Attendance 36.

Indianapolis-Lafayette

Operating Experiences with the A. C. Network Method of Power Distribution, by F. E. Pinckard, Union Gas & Electric Co., Cincinnati. Program followed by smoker and social time. May 3. Attendance 67.

Ithaca

The Future of This Mechanistic Age, by Ralph Flanders, General Mgr., Jones & Lamson Co., Vice-President, A. S. M. E., who spoke for E. A. Sperry. R. F. Schuchardt, President A.I.E.E., gave a talk which took the form of an inspiration to young engineers. Banquet and joint meeting with Cornell University Branch, A. S. M. E. March 15. Attendance 220.

The Present Status of Railway Electrification, by N. W. Storer, Consulting Railway Engr., Westinghouse Electric & Mfg. Co. Illustrated. April 19. Attendance 32.

Kansas City

Broader Aspects of Engineering, by E. B. Black, Consulting Engr. A very interesting discussion followed, the trend of which was that it is the duty of the engineers themselves to get a better appreciation of their profession by the public.

The High-Pressure Installation Northeast Station, by J. A. Keeth, Assistant to the Vice-President in Charge of Production, Kansas City Power & Light Co. Slides. Coffee and sandwiches served. Jount with Kansas City Section, A. S. M. E. April 29. Attendance 200.

Lehigh Valley

Electrical Applications in Automotive Plants, by W. P. Mitchell, International Motor Co. Slides.

The National Electrical Code, by A. R. Small, Vice-President, Underwriters' Laboratories. J. L. Beaver, Vice-President, Middle Eastern District, gave a brief address. The meeting, held at Allentown, was preceded by a dinner, April 19. Attendance 179.

Los Angeles

Recent Developments in Electrical Research, by C. E. Skinner, Asst. Director of Engg., Westinghouse Electric & Mfg. Co. Joint meeting with local Section, A. S. M. E., preceded by a dinner. April 2. Attendance 120.

Lynn

Gaseous Discharges, by Clifton Found, Research Laboratory. General Electric Co. Demonstration of new 110-volt Neon Lamp. April 10. Attendance 125.

The Story of Steel, by G. A. Richardson, Mgr., Technical Publicity Dept., Bethlehem Steel Co. Illustrated by seven reels of moving pictures. Beverly, Mass. April 24. Attendance 175.

Madison

Some Recent Research Developments of the Westinghouse Electric & Mfg. Co., by C. E. Skinner, Asst. Director of Engg., Westinghouse Electric & Mfg. Co. Demonstrations of photoelectric devices and grid-glow tube. April 16. Attendance 61.

Mexico

Dinner meeting for promoting friendly relations with the local engineering societies, representatives of four of which were present. February 12. Attendance 38.

Farewell dinner to Chairman P. M. McCullough. March 26. Attendance 18.

Nebraska

Joint meeting with A. S. M. E. Section and students. See report in Student Activities dept. April 17.

New York

Student Convention and evening meeting of Section. Complete report in Student Activities dept. April 26. Attendance 700.

Niagara Frontier

Thyratron Control, by F. E. Vogdes, Research Laboratory, General Electric Co. Slides. Demonstration apparatus. Dinner for the speaker held prior to the meeting. Joint with Engineering Society of Buffalo. February 15. Attendance 65.

What a Serious Accident Means to the Injured Man and Also to the Company, by J. C. VanVleet, Safety Engineer, Buffalo General Electric., and

200,000 K. W. Hydroelectric Development, by W. S. Murray, Murray and Flood. Illustrated with motion pictures and slides. Mr. Murray was entertained at a dinner. March 22. Attendance 110.

Pittsburgh

Inspection trip to Lake Lynn Hydroelectric Generating Station, West Penn Power Co. on the Cheat River, West Virginia. Guests of West Penn Power Co. at dinner in Uniontown, Pa. April 13. Attendance 225.

Pittsfield

High-Power Transmission and Transformers, by F. F. Brand, General Transformer Engg. Dept., General Electric Co. Speaker was entertained at dinner. March 19. Attendance 75.

Annual Dinner. Captain Irving O'Hay, U. S. Army, Retired, Humorist, Traveler and Lecturer. April 2. Attendance 222.

Researches with Natural and Artificial Lightning, by F. W. Peek, Jr., Consulting Engr., General Electric Co. Slides and moving pictures. Joint meeting with Springfield Section and Engineering Society of Western Massachusetts. Speaker was entertained at dinner. April 16. Attendance 250.

Providence

The New England Power Association's System, by C. R. Oliver, Vice-President, New England Power Association. Joint with Providence Engineering Society and Providence Section, A. S. C. E. April 23. Attendance 140.

Rochester

Hum Elimination in All-Electric Radio Receivers, by B. F. Miessner, Elec. and Acoustical Engr., Joint meeting with Rochester Engg. Society and Rochester Section, I. R. E. Dinner in honor of speaker. April 19. Attendance 71.

Annual business meeting. The following officers were elected; Chairman, V. M. Graham; Vice-Chairman, H. J. Klumb; Secretary, C. F. Estwick; Executive Committee, D. C. Jones, H. C. Ward, A. E. Soderholm and E. C. Karker. After the business meeting a joint meeting was held with the Rochester Engineering Society. Motion picture, "Hoover, Master of Engineers." May 3. Attendance 32.

St. Louis

Structural Development of the Deion Circuit Breaker up to 15,000 Volts, by R. C. Dickinson, Westinghouse Electric & Mfg. Co. Illustrated. Attendance prizes awarded to S. V. Hornbeck and H. O. Deutscher. Amendments to Section By-laws adopted. The following officers were elected: Chairman, G. H. Quermann; Vice-Chairman, C. B. Fall; Secretary-Treasurer, O. J. Rotty. April 17. Attendance 83.

San Francisco

Recent Research Development of the Westinghouse Electric & Mfg. Company, by C. E. Skinner, Asst. Director of Engg. of that company. Display of various materials and demonstration of super-sensitive vacuum tubes. Dinner preceded the meeting. March 29. Attendance 130.

Annual joint meeting with neighboring Branches. See report in Student Activities dept. April 10.

Schenectady

Aviation, by W. P. McCracken, Jr., Asst. Secretary of Commerce for Aeronautics. March 22. Attendance 200.

Seattle

Joint meeting with University of Washington Branch. See report in Student Activities dept. April 16.

Sharon

Long Distance Toll Cable Transmission, by J. A. Cadwallader, Engineer of Transmission and Outside Plant, Bell Telephone Co. of Pa. Moving pictures. Demonstration of effect of speech and music of the suppression of various frequency bands. April 2. Attendance 76.

Syracuse

Assessment Records in Rochester, by H. C. Bratt, Rochester Bureau of Municipal Research. March 11. Attendance 63.

Toledo

Circuit Breakers, by Mr. Edsel, Condit Mfg. Co. Slides. Two reels of motion pictures on the construction of transformers, turbines, blast furnace blowers, etc. One reel on the assembly and testing of electric locomotives for the St. Gothard Railway Co., Switzerland. April 12. Attendance 35.

Toronto

Building of the Leaside Transformer Station, by G. E. Kewin. Slides. C. F. Publow spoke on the theoretical considerations involved in the design of this station. April 12. Attendance 116.

Joint meeting with Hamilton Section, Engineering Institute of Canada. J. V. Breisky, Westinghouse Electric & Mfg. Co., demonstrated photo-electric glow discharge devices and their applications to industry. Slides. Persons coming into the hall were counted automatically as they interrupted a beam of light across the entrance. April 26. Attendance 560.

Urbana

Joint meeting with student groups. See report in Student Activities dept. April 20.

Utah

Electrical Transmission of Speech and Music, by H. W. Oddie, Utah Transmission and Protection Engr., The Mountain States Telephone and Telegraph Co. Slides. April 15. Attendance 75.

Annual student program. See report in Student Activities dept. May 13.

Vancouver

Aeroplane Design, by Prof. Vernon, University of British Columbia. Members of Engineering Institute of Canada and Aeronautical organizations in the city invited. April 10. Attendance 78.

Contract Law, by R. W. Ginn, Barrister & Solicitor, Vancouver. Engineering Institute of Canada members invited. May 7. Attendance 16.

Washington

Some New Industrial Economics, by Dean D. S. Kimball, College of Engineering, Cornell University. Talk followed by social hour and light refreshments. Preceding the meeting a dinner was served in honor of the speaker. Apirl 9. Attendance 79.

Worcester

Physical Principles Involved in Television, by Dr. J. O. Perrine, American Tel. & Tel. Co. February 13. Attendance 350.

Research in Engineering, by T. W. Spooner, Asst. Mgr., Research Dept., Westinghouse Electric & Mfg. Co. March 8. Attendance 100.

Edison and His Inventions, by W. J. Hammer, Consulting Electrical Engineer. April 15. Attendance 100.

A. I. E. E. Student Activities

FOURTH STUDENT BRANCH CONVENTION, NORTH EASTERN DISTRICT, A. I. E. E.

The fourth annual Student Branch Convention of the North Eastern District of the A. I. E. E. was held at Rensselaer Polytechnic Institute, Troy, N. Y., on Friday and Saturday, May 10-11, 1929.

The total registration of 262 included 86 students and 11 professors from Rensselaer, 146 students and 13 professors from other institutions in the district, as well as representatives of the different Sections of District No. 1.

The schools represented were Clarkson College of Technology, Cornell University, Harvard Engineering School, University of Maine, Massachusetts Institute of Technology, University of New Hampshire, Northeastern University, Rensselaer Polytechnic Institute, Rhode Island State University, University of Vermont, Worcester Polytechnic Institute, Syracuse University and Yale University.

The Friday morning session, presided over by S. E. Benson of Rensselaer, was opened with an address of welcome by President Palmer C. Ricketts of Rensselaer. The session was given over to a discussion of Branch activities during the past year. About 200 attended this session.

At 11:30 a. m. the District Executive Committee met, and, among other subjects, discussed plans for the 1930 Regional Meeting at Springfield, Mass.

At 12:30 p. m. the Luncheon Conference of incoming Branch Chairmen and Branch Counselors was held at the Hendrick Hudson Hotel. The Counselors and Chairmen were joined at luncheon by the members of the District Executive Committee.

The Friday afternoon session, presided over by R. M. Durrett of M. I. T., was devoted to the presentation and discussion of eight technical papers. The authors of these papers were J. L. Daley and A. F. Metzger of Yale, M. M. Hubbard of M. I. T., L. B. Hoefgraf of Rensselaer, T. A. Rich of Harvard, H. E. Furman and T. S. Bills of Cornell, E. W. Jones of Maine, E. R. Gardner and A. A. Jones of M. I. T., and A. H. Coon of Rhode Island State. The papers were ably presented and discussed. About 300 attended this session.

The Convention Banquet given by Rensselaer Polytechnic Institute without charge to guests was held on Friday evening. Music was furnished by the Student Quartette and by the Campus Serenaders. Doctor W. L. Robb, Head of the Electrical Engineering Department, made a few opening remarks and introduced Mr. A. C. Stevens, the District Secretary, who presented the Branch Paper Prize to Mr. S. R. Knapp and Mr. J. R. Burnett of Cornell, and announced as winners of the First Paper and Best Paper Prizes, Professor H. H. Race of Cornell and Mr. C. F. Estwick of the Rochester Section. Doctor Robb also introduced Doctor W. R. Whitney, Director of the Research Laboratory of the General Electric Company, who gave a very interesting talk on the value of having a hobby.

On Saturday, inspection trips arranged by the Schenectady Section were made. The Schenectady Works of the General Electric Company were visited in the morning, after which a complimentary luncheon given through the courtesy of the General Electric Company, was enjoyed at the Schenectady Y. M. C. A. After luncheon the party inspected the Erie Barge Canal lock at Cranesville and the Amsterdam Steam Plant of the New York Power & Light Corporation.

NEW YORK SECTION STUDENT BRANCH CONVENTION AND SECTION MEETING

On Friday April 26th the New York Section held its fourth Annual Student Branch Convention and also the monthly Section meeting. All details f the Student activities were arranged by committees appointed by the students themselves, and were all under the direction of a general student convention committee. For the morning April 26, five inspection trips were scheduled by and for the students only as follows: Bell Telephone Laboratories; American Telephone and Telegraph Company; Brooklyn Navy Yard; Lackawanna Railroad Company; and Brooklyn Edison Company.

The afternoon session, starting at 2 p. m. in the Engineering Auditorium, was devoted to the competition for the New York Section Student Prize of $25.00 in gold. George A. Taylor was presiding officer and chairman of the Student Convention Committee. Each of the seven students representing seven colleges was limited to exactly 15 minutes for presentation. The following list gives speakers and their subjects:

Interconnection of Power Systems, by C. M. Stuehler of Newark College of Engineering;
Frequency Stabilization, by L. O. Foernsler of Cooper Union;
Trends in Systems of Railroad Electrification, by H. M. Hobson of Rutgers;
The Condenser Motor, by I. Galante, College of City of New York;
Sound Recording, by A. W. Schneider, New York University;
An Ultra-Violet Photometer, by J. G. Trump, Polytechnic Institute of Brooklyn;
Some Aspects of Machine Switching, by E. J. Moore, Stevens Institute.

All presentations, given largely without reference to the written text, were extremely well done so that the judges Messrs. A. H. Kehoe, L. W. Morrow and R. R. Kime found it difficult to select a winner, but J. G. Trump of the Polytechnic Institute was ultimately chosen. This award is the fourth made successively to a student of the Polytechnic.

In addition to the student presentations, Chairman Tapscott of the New York Section made an address of welcome in opening the session and after the presentation of the fourth paper there was an intermission during which a movie comedy was presented. A student dinner was held at the Fraternity Club at 6 p. m., Farley Osgood, Past-President of the Institute giving a short after-dinner talk to the students on the problems faced upon graduation. Some 350 students attended the afternoon session and the dinner.

The regular New York Section monthly meeting was held at 8:15 p. m. in the Engineering Auditorium, the speaker of the evening being Colonel Hugh L. Cooper, consulting engineer of New York, who gave an address on "Russia." Colonel Cooper has been engaged in extensive hydroelectric developments in Russia and has traveled widely within its borders. He has made a practise of studying the situation in Russia thoroughly from all angles and has interviewed Russians of every type and class. His address very graphically presented, was of great interest and was followed by a long period of discussion with Colonel Cooper answering many queries.

Preceding the talk on Russia the announcement of the election of officers of the Section for 1929-30 was made. Amendments to the Section By-laws providing for the Group Activities were passed. Presentation of the prize to the winner of the Student Branch competition was also made. Attendance totalled about 350.

STUDENT ACTIVITIES AT DALLAS REGIONAL MEETING

In making plans for the Regional Meeting of the South West District held in Dallas, Texas, May 7-9, 1929, the committees in charge gave special attention to the student activities. A program of special interest to Section and Branch representatives was arranged for the second session of the meeting Tuesday afternoon and a student session was held on Wednesday morning.

All of the 177 students attending the regional meeting, most of whom were from outside of Dallas, showed great interest in various sessions in addition to those at which student programs were presented as indicated below.

TUESDAY AFTERNOON

Remarks, R. F. Schuchardt, President, A. I. E. E.

Substation Design, T. E. Peter, Chairman, University of Arkansas Branch.

Piezo-Electric Crystal-Controlled Oscillators, LeRoy Moffett, Jr., Secretary, University of Oklahoma Branch.

Frequency Stability of Split-Anode Magnetron Oscillators, Norvel Douglas, Chairman, University of Kansas Branch.

Solution of Electrical Networks by the Use of a General Network Theorem, L. E. Brown, University of Texas.

The Effect of Terminating Impedances on the Characteristics of Filters, Harold J. Miller, Chairman, Washington University Branch.

WEDNESDAY MORNING

Opening Remarks, B. D. Hull, Vice-President, South West District, A. I. E. E.

Student Activities, H. H. Henline, Assistant National Secretary, A. I. E. E.

General Discussion of Student Activities.

A Method of Investigating Surface Iron Losses, R. A. Foltz and H. E. Gove, University of Missouri.

Positive Directions as Applied to Electric and Electro-Magnetic Circuits, G. W. Beams and E. L. Andrews, Texas A. & M. College.

Performance of Standard Transformers Connected as Auto-Transformers, J. J. Loving and C. R. Redden, Texas A. & M. College.

Supervision of Gas, Electric and Water Meters in Texas, W. T. Henrichson, University of Texas.

A Universal Deficiency-Compensating Amplifier, J. E. Peek, Oklahoma A. & M. College.

A Graphical Solution of Networks, E. G. Downie, Kansas State Agricultural College.

A handsome cup had been provided for award to the Branch represented by the student who presented the best technical paper. At the close of the Wednesday morning session, the decision of the judges was announced by President Schuchardt, who presented the cup to the University of Oklahoma Branch, for the paper delivered by its Secretary, LeRoy Moffett, Jr., entitled "Piezo-Electric Crystal-Controlled Oscillators."

THURSDAY LUNCHEON

At a luncheon Conference of Counselors and officers of the Institute, held on Thursday, Dean George C. Shaad of the University of Kansas was re-elected Chairman of the District Committee on Student Activities.

Various problems encountered in the conduct of Branch work were discussed and each of the nine Counselors present gave brief statements regarding the principal activities of his Branch. Ways and means of increasing interest in Branch meetings were mentioned, and considerable emphasis was placed upon the desirability of having nearly all of the papers presented by students. The value of occasional moving picture films, debates, smokers and dinners was recognized.

ANNUAL COLLEGE BRANCH NIGHT OF DENVER SECTION

The annual meeting of the Denver Section with students of the neighboring schools was held on April 26 with a total attendance of 90. The meeting was preceded by a dinner, at which 36 students from the University of Colorado, University of Denver, and Colorado School of Mines were guests of the Section. The following papers were presented by students:

Some Factors Affecting the Power Limits of Transmission Systems, W. A. Merriam, University of Colorado.

Uses of Electricity in Metallurgy with Special Reference to the Production of Electrolytic Iron, James Ogilvie, Colorado School of Mines.

Variation of the Pole Strength of a Permanent Magnet as Dependent upon Its Weight, F. A. St. John, University of Denver.

Dean O. J. Ferguson, Vice-President of the North Central District, gave a brief address on the obligation of individuals to the electrical industry.

ANNUAL STUDENT MEETING OF SAN FRANCISCO SECTION

The annual joint meeting of the San Francisco Section and the Student Branches at the University of California, University of Santa Clara, and Stanford University was held at the Engineers Club in San Francisco on April 10, with an attendance of 165, and was preceded by an informal dinner attended by about 90 members and visitors.

The following program was presented by students:

Design Equations for Vacuum Tube Voltmeters, Harry R. Lubcke, University of California.

Voltage Surges in Audio Frequency Apparatus, Elmer H. Fisher, Stanford University.

Characteristics of Electrostatic Loud Speakers, F. J. Somers, University of Santa Clara.

Entertainment was supplied by University of Santa Clara students.

The papers showed a great deal of thought and study and were presented in an interesting manner. On account of the nature of the subjects discussed, members of the San Francisco Section of the Institute of Radio Engineers were invited, and about 20 were present.

These joint meetings have proven very popular and have served to bring the students into contact with the older men of the profession.

ANNUAL STUDENT MEETING OF UTAH SECTION

The annual joint meeting of the Utah Section and the University of Utah Branch for the presentation of student papers was held at the Newhouse Hotel in Salt Lake City on May 13, with an attendance of 45.

The following papers based upon thesis work done by the students were presented:

Voltage Distribution on High-Tension Insulators, Floyd Gowan and Ned Chapman.

Impedance Curves of Some Loud Speaker Units, D. W. Hatfield and C. M. Bisbee.

The Location of Inductive Interference and Its Elimination by a Network, Jay R. Wrathall and Andrew Watt.

The papers were well presented and interesting discussions followed.

PAST BRANCH MEETINGS

Alabama Polytechnic Institute

Business Meeting. Election of Officers. April 18. Attendance 28.

T. C. I. Plant in Birmingham, by N. W. Geist, '29, and *The Empire Coal Mine*, by C. D. Bradley, '29. Impromtu talks by J. R. Alexander, W. T. Edwards, and W. R. Coleman, students. April 25. Attendance 32.

Following talks by students: *Automatic Telephone Equipment*, by W. T. Edwards; *What Price Television*, by Paul Brake; *Squeezing Gas Out of Iron and Steel*, by R. A. Mann; *What the A. I. E. E. Means to Me*, by J. R. Alexander; *Boyhood Experiments*, by P. C. Avant; *Microphone Adjustments*, by A. C. Cohen; and *Methods of Cooling Transformers*, by W. F. Nabers. May 2. Attendance 23.

University of Arkansas

Wave Traps and Band Pass Filters in Radio Circuits, by James Boswell, student. March 21. Attendance 15.

Brooklyn Polytechnic Institute

Four papers presented in competition, the winning paper to be presented at New York Section Student Convention: *Regenerative Crystals*, by A. W. Nagy; *Traffic Signals*, by

Thomas Detwiler; *Accelerometers*, by George Logan, and *Talking Pictures*, by John Trump. J. Trump declared winner of contest. Refreshments served. March 8. Attendance 48.

Oscillographs, by C. A. Mead, Westinghouse Electric & Mfg. Co., Newark. Refreshments served. April 19. Attendance 41.

California Institute of Technology

New and Interesting Phases of Electrical Engineering, by Dean P. S. Biegler, University of Southern California. May 2. Attendance 20.

University of California

The General Electric Test Course, by Prof. T. C. McFarland, Counselor. Slides. C. W. Mors, student, gave an explanation and demonstration of his newly devised radio circuit. John A. Reynolds, A. S. U. C. President-elect, gave a brief review of his plans. Election of officers. April 17. Attendance 22.

Carnegie Institute of Technology

The Recording and Reproduction of Sound in Connection with Motion Pictures, by Harry Greenman, student. J. R. Britton, Chairman-elect, presented a report upon the Regional Meeting in Cincinnati. Short social meeting. April 10. Attendance 32.

Case School of Applied Science

Senior Farewell Dinner, followed by theater party. Branch business turned over to the newly elected officers. May 1. Attendance 38.

University of Cincinnati

Atomic Hydrogen Welding, with demonstration, by J. E. Middleton, '29. Election of officers. April 4. Attendance 53.

Clarkson College of Technology

Inspection trip to Massena Works of the Aluminum Company of America. April 17. Attendance 32.

Papers presented by students as follows: *The Art of Arc Welding*, by C. F. Vaughn; *The Economics of Arc Welding*, by W. F. Cooney; *Aeronautical Instruments*, by K. T. Henry; and *Development of Aviation*, by H. J. Sullivan. April 20. Attendance 26.

Annual election of officers. April 25. Attendance 57.

Following papers presented by students: *The Progress of Railway Electrification*, by G. W. Aucock; *The Theoretical and Field Study of Lightning Discharges*, by F. A. Grant; and *The Manufacturing of Ice Cream*, and *Other Ammonia Freezing Installations*, by J. M. Kimball. April 27. Attendance 22.

Colorado Agricultural College

The Photoelectric Effect, by Dr. F. L. Poole, Associate Professor of Electrical Engineering. January 14. Attendance 13.

Three-reel motion picture showing construction and manufacture of insulated wire. April 15. Attendance 12.

University of Colorado

Manufacture and Calibration of Electrical Measuring Instruments, by A. S. Corby, Jr., Weston Electrical Instrument Corp. Slides. Refreshments. April 24. Attendance 30.

Cooper Union

Frequency Stabilization, with demonstrations, by Louis Fernsla. April 10. Attendance 10.

University of Denver

Demonstration given by representatives of the General Electric Company of some experiments on the relation between life and cost of an electric lamp, and magnetic braking and motor control. March 29. Attendance 105.

Motion pictures, entitled "Street Lighting" and "Driving the Longest Railroad Tunnel in the Western Hemisphere." April 12. Attendance 76.

Business Meeting. April 24. Attendance 15.

Business Meeting. Following officers were elected for next year: President, L. J. Wright; Vice-President, H. H. Ward; Secretary, R. B. Convery; Corresponding Secretary, G. W. Bindschadler. May 1. Attendance 11.

University of Detroit

Uses of Psychology in Factory Maintenance, by E. E. Walerych, Elec. Engr. and Supt. of Maintenance, Plymouth Plant, Chrysler Corporation. Film: "Description and Operation of the Radio Beacon in Aviation." April 18. Attendance 35.

Duke University

Mathematical Short-Cuts, by S. G. Lindsay, Jr., '30, and

Radio Application to Railroad Signal Systems, by C. W. Berglund, Jr., '29. April 19. Attendance 19.

University of Florida

Business Meeting. Following officers were elected: Chairman, J. W. McKay; Vice-chairman, L. R. Bassett; Secretary-Treasurer, A. L. Webb. April 29. Attendance 15.

Georgia School of Technology

Inspection trip to the Atlantic Steel Mills, Atlanta. April 10. Attendance 45.

University of Idaho

Talks on their work during past summer by the following students: H. Hattrup, Bell Telephone Co.; Fred Dicus, Clearwater Timber Co.; Orland Mayer, Washington Water Power Co.; and Bob Olin, Clearwater Timber Co. March 13. Attendance 30.

Forests, by L. D. Schmitz, '29, and

Steinmetz, by J. L. Thomason, '29. F. E. Dicus, Jr., elected Secretary-Treasurer. Dinner meeting. March 20. Attendance 32.

Iowa State College

Business Meeting. The following officers were elected: President, H. H. Stahl; Vice-President, Phil Pryor; Secretary-Treasurer, H. Kirk. April 24. Attendance 24.

Kansas State College

Current Events in Engineering World, by A. R. Wecke, Jr., student, and

Design of Long Distance Telephone Circuits to Provide Satisfactory Transmission, by A. B. Covey, Transmission and Protection Engr., Southwestern Bell Tel. Co., and Secretary, Kansas City Section. Election of officers. April 4. Attendance 138.

University of Kansas

Westinghouse Student Course, by Mr. Randel;

Dates of Important Discoveries and Developments in the Electrical Field, by Mr. Leonard, and

The Modern Radio Receiver, by Mr. Baxter. Entertainment. April 11. Attendance 58.

Business Meeting. The following officers were elected for next year: Chairman, M. W. Hammond; Vice-Chairman, O. N. Magers; Secretary, H. W. Yenzer; Treasurer, Wayne Powell; Senior Representative, Leslie Flory; Junior Representative, G. E. Berg. April 25. Attendance 80.

Lehigh University

Recent Developments in the Electric Utility Systems, by Raymond Bailey, Asst. Elec. Engr., Philadelphia Electric Co. and Secretary, Middle Eastern District, A. I. E. E. Illustrated.

Summer Experiences, by R. S. Taylor, '29. A prize of $10.00 was awarded to L. K. Sowers for the best student paper of the year. The following newly-elected officers were in charge of the meeting: President, B. O. Steinert; Vice-President, R. A. Baker; Secretary, J. E. Zeaser; Treasurer, P. A. Bahr. May 2. Attendance 58.

Lewis Institute

Four motion pictures: "Building New York's Newest Subway," "Driving the Longest Railroad Tunnel in the Western Hemisphere," "Dynamite, the Modern Ditch Digger," and "Letting Dynamite Do It." May 8. Attendance 100.

Louisiana State University

Motion picture—"The Story of Dynamite." March 21. Attendance 22.

Motion pictures—"Driving the Longest Railroad Tunnel in the Western Hemisphere" and "Building New York's Newest Subway." April 1. Attendance 26.

Massachusetts Institute of Technology

An Outline of the Development of Electric Illumination, by C. A. Turner, '29, and

Lighting in Industry, by M. M. Hubbard, '29. March 22. Attendance 15.

Inspection trip to Edgar Station of the Edison Electric Illuminating Company of Boston. March 28. Attendance 50.

An Introductory Discussion of the Gasoline-Electric Drive, by A. A. Jones, student, and

Application of the Gasoline-Electric Drive to Pleasure Vehicles, by E. R. Gardner, student. Luncheon meeting. May 1. Attendance 76.

University of Maine

Lightning Disturbances on Transmision Lines, by E. W. Jones, '28. Following officers elected: President, A. E. Crockett; Vice-President, E. P. Bailey; Secretary-Treasurer, H. R. Mayers. April 18. Attendance 38.

Montana State College

Direct Scanning in Television, by Frank Gray, from Bell Laboratories Record, March, 1929. Presented by Frithiof Johnson, student.

Some Developments in the Electrical Industry During 1928, by John Liston, from *General Electric Review*, January 1929. Presented by Vincent Morgan, student.

Talking Movies by the Density Method, by Donald MacKenzie, from the *Bell System Technical Journal*, January 1929. Presented by Joseph Hurst, student. April 11. Attendance 50.

High-Voltage Mercury Arc Rectifiers, by L. Smede, from *Electric Journal*, August 1928. Presented by Homer Morton, student.

Advances in Industrial Lighting Practise, by A. D. Bell, from A. I. E. E. Journal, April 1929. Presented by Earle Rudberg, student. Three-reel film—"Electric Arc Welding." April 25. Attendance 61.

Smoke Precipitator, by E. T. Braden, student;

Rural Power Electrification in Gallatin Country, by Foster Buck, student, and

Electric Thermometers for the Stars, by H. N. Russell, from the Scientific American, May 1929. Presented by Harrell Renn, student. May 2. Attendance 68.

University of Nebraska

Experiences in Summer Employment, by H. E. Cook and Otto Saar, students. Plans for "Engineers Week" were discussed. Film—"Largest Single Unit Electric Locomotive," April 24. Attendance 35.

Newark College of Engineering

Evolution of the Elevator, by S. C. Lawson, Sales Engr., Otis Elevator Co., and G. K. Stackpole, of the same company. April 15. Attendance 24.

Electrolysis, by L. Hompesch, New Jersey Bell Telephone Co. May 6. Attendance 25.

University of New Hampshire

Transient Disturbances on Transmission Lines, by T. Elliott, student, and

District Representative Plan in the Black Valley, by G. Sumner, student. October 13. Attendance 26.

Two motion pictures—"Telephone Current" and "Artificial Respiration." Following officers elected: Chairman, Philip Nudd; Secretary, Danforth Coogins. April 6. Attendance 32.

Following talks by students: "Turbine-Electric Drive for Ship Propulsion," by R. G. Ballard; "Aircraft Compass Problems," by W. S. Bartlett; and "Construction of the Vacuum Tube," by A. W. Boyles. April 13. Attendance 30.

Following talks by students: "Electrical Progress in Japan," by J. K. Clark; "The Deion Circuit Breaker," by J. J. Donnelly; and "Measurement of Reactance with the Wheatstone Bridge," by N. J. Pierce. April 20. Attendance 30.

Raising the Load Factor, by H. Duquette, student, and

Tests on Glazed Insulators, by B. C. Files, student. As a means of increasing the interest in the meetings of the Branch, two or three students are called upon each week to speak extemporaneously on topics assigned by the Chairman. This feature is in addition to the regular program. April 27. Attendance 28.

College of the City of New York

Motion picture—"Modern Manufacturing with a 'Stable-Arc' Welder." May 9. Attendance 37.

North Carolina State College

The following officers were elected: Chairman, H. W. Horney; Vice-Chairman, D. E. Jones; Secretary-Treasurer, E. R. Price; Member of Engineering Council, W. W. Weltmer; Reporter, T. S. Ellington. April 16. Attendance 18.

Business meeting. May 7. Attendance 8.

University of North Carolina

The following program was given by students: *The History of the Telephone*, by H. J. Hines, Jr.; *Professional Relations of the Electrical Engineer*, by W. B. Massenburg; and *The Development of the Electric Railway*, by J. W. Holt, Jr. April 18. Attendance 32.

Lightning Effects on Transmission, by Wayne Bursh, Carolina Power & Light Co., and

Effects of Transmission Lines on Long Distance Telephone Lines, by Mr. Jenkins, of the same company. Following the regular meeting, a smoker was held. May 2. Attendance 32.

University of North Dakota

Still film—"Mercury Arc Rectifier." The following officers were elected: Chairman, R. W. Olson; Vice-Chairman, J. S. McKechnie; Secretary-Treasurer, G. E. Glass. May 2. Attendance 21.

Northeastern University

The Development of Television, by J. W. Horton, Chief Engr., General Radio Co. Slides. April 23. Attendance 50.

University of Notre Dame

Indiana-Michigan Electric Company Lines, by H. J. Kiely and E. P. Kreimer, Indiana-Michigan Electric Co. Election of officers. Refreshments served. April 29. Attendance 60.

Ohio Northern University

Business Meeting. February 28. Attendance 21.

Modern Electric Equipment in R. R. Systems, y Robert Davis, student. March 21. Attendance 22.

Prof. I. S. Campbell, Counselor, emphasized several of the many advantages in membership in the A. I. E. E. President McGahan reported upon the Regional Meeting in Cincinnati. April 18. Attendance 16.

Electrical Equipment Used in Salt Mining, by A. Schifino, student, and

Oil Circuit Breakers, by H. R. Garn, student. May 2. Attendance 21.

Ohio University

Business meeting. October 31.

Inspection trip to the electrically operated coal mine of the Boston Coal Company, Millfield, Ohio. February 13. Attendance 12.

Three-reel film—"Arc-Welding." April 18. Attendance 28.

Motion picture—"Driving the Longest Railroad Tunnel in the Western Hemisphere." April 25. Attendance 25.

Oklahoma A. & M. College

Business session. Four-reel picture "Fifty Years of Telephone Progress." April 25. Attendance 30.

Oregon State College

Electrical Measuring Instruments, by A. S. Corby, Jr., Educational Department, Weston Electrical Instrument Corp. April 5. Attendance 52.

Chairman Mize gave a report on the Conference on summer employment which he attended in Portland. Prof. F. O. McMillan, Counselor, gave a resume of the accomplishments of the conference. April 22. Attendance 21.

Prof. F. O. McMillan, Counselor, announced that the prize for the best student paper in the North West District had been won by Paul Klev and Audrey Shirley for their paper entitled "The Determination of Voltage Ratio of Audio Frequency Transformers by Means of the Cathode Ray Oscillograph." May 1. Attendance 22. The following officers were elected on May 6: Chairman, B. G. Griffith; Vice-Chairman, R. B. Haight; Secretary-Treasurer, D. C. Gillanders.

University of Pennsylvania

Following officers elected: Chairman, R. R. Creighton; Vice-Chairman, F. C. Iglehart; Secretary, Newbern Smith; Treasurer, J. S. Moore, Jr. March 18. Attendance 27.

University of Pittsburgh

One-reel picture—"Water Power." March 22. Attendance 42.

Japanese Power Development, by S. Q. Hayes, General Engr., Westinghouse Electric & Mfg. Co. April 5. Attendance 56.

Work with the Wagner Electric Corporation, by J. O. Pattillo, '26. Chairman J. B. Luck gave a report on the Student Activites Session at the Cincinnati Regional Meeting. April 12. Attendance 63.

Processes and Equipment Used in Obtaining Copper Electrolytically from the Low Grade Ore of a Mine in Chile, by G. W. Goebel, Superintendent, Inspection & Testing Depts., Westinghouse Elec. & Mfg. Co. April 19. Attendance 66.

Business session. Motion picture "The History of Transportation." May 3. Attendance 67.

Princeton University

Deion Circuit Breaker, by W. K. Murray, student. April 10. Attendance 8.

Purdue University

Relativity, by C. S. Roys, Instructor in Elec. Engg. Business session. March 2. Attendance 20.

The Dynamic Speaker, by W. H. C. Higgins, III, student. Election of officers. April 16. Attendance 45.

Rensselaer Polytechnic Institute

The Use of Series Capacitors in Transmission Lines, by T. A. E. Belt, General Electric Co. Complete demonstration given. March 12. Attendance 150.

Television, by R. A. Deller, Bell Telephone Laboratories, Inc. Motion pictures and apparatus. Election of officers. April 9. Attendance 402.

Rhode Island State College

Development of Power in New England, by T. H. Lloyd, student, and

Early Power Plants, by Edward Kenyon, student. December 19. Attendance 13.

Developments of 1928, by F. E. Caulfield, student. April 12. Attendance 14.

Inspection trip to Narragansett Electric Power Station at Providence, Dyer Street Substation, and the Industrial Trust Building. April 19. Attendance 14.

Hydrogen-Filled Synchronous Condenser, by F. E. Caulfield, student;

Condenser Motor, by A. H. Coon and Arnold Judkins, students, and

Radio Spectrum, by A. Z. Smith, student. April 26. Attendance 16.

Prof. William Anderson, Counselor, announced plans for the Student Convention at Troy. Election of officers. May 3. Attendance 18.

Rutgers University

The Rocky River Hydro Development, by President J. Cost, and

The Development of the Mercury Arc, by Prof. P. S. Creager, Counselor. March 26. Attendance 24.

Sound Recording with Light Valve, by E. Wilson, '29, and

Transmission Troubles in California Power Lines, by T. Stauber, '30. April 19. Attendance 18.

The Graphical Solution of A-C. Transmission Problems, by Mr. Wolf, '29, and

The Electrolytic Zinc Plant of the Sullivan Mining Company, by L. Gorka, '30. April 16. Attendance 20.

University of Santa Clara

Inspection trip to the Hetch-Hetchy Power and Water Project. Joint function of the Branch and the University of Santa Clara Engineering Society. April 13-15. Attendance 29.

Inspection trip to the General Electric Company's Radio Broadcasting Station KGO and to the General Electric Company's lamp factory, Oakland, California. April 17. Attendance 23.

Inspection trip to Station "C", Pacific Gas & Electric Co., Oakland. May 1. Attendance 24.

Business Meeting. Following officers elected: Chairman, T. L. Selna; Vice-Chairman, G. W. Vukota; Secretary, J. D. Gillis. May 5. Attendance 27.

South Dakota State School of Mines

Electrical Measuring Devices, by A. S. Corby, Weston Electrical Instrument Corp. April 29. Attendance 41.

Film—"The Single Ridge." April 11. Attendance 20.

University of South Dakota

Business Meeting. April 29. Attendance 14.

University of South rn California

Development of the Electric Power Industry in Los Angeles, by E. R. Northmore, Supt. of Electric Distribution, Los Angeles Gas & Electric Corp., and Vice-President, Pacific District, A. I. E. E. April 11. Attendance 60.

The Reconstruction of Power Plant No. 2 on the Los Angeles Aqueduct, C. M. Allen, Construction Engr., Dept. of Water and Power, City of Los Angeles. April 25. Attendance 110.

Stanford University

A Harmonic Generator, by E. H. Fisher, graduate student, and

Methods of Training an Engineer in England, by R. H. Angus (Yorks, England), graduate student. April 3. Attendance 23.

C. H. Delaney, Pacific Gas and Electric Co., spoke on Station C, the new steam plant of that company in Oakland. April 22. Attendance 23.

Inspection trip to Station C. April 27. Attendance 17.

Stevens Institute of Technology

The Economics of Locomotive Assignment, by W. Titus, student. Two-reel film to illustrate. Smoker of Stevens Engineering Society. Refreshments were served. April 24. Attendance 40.

Syracuse University

Calculation of Forces on Automatic Circuit Breakers, by Mr. Allen, student, and

Electrification of a Steel Mill, by Mr. Casavant. W. B. McCann, Chairman of the Syracuse Section, discussed the papers. The relationship between the Section and the Branch was discussed. Following the meeting, a luncheon was given in honor of Mr. McCann. February 28. Attendance 22.

Following talks by students: "Spacing of Poles on a Transmission Line," by Mr. Noxon;

Trolley Pole Design, by Mr. Martin. April 11. Attendance 21.

Selection of a Transformer, by Mr. Zogby, student, and

Electrification of a Rolling Mill, by Mr. Warntz, student. April 25. Attendance 21.

University of Tennessee

Film—"The Single Ridge." February 15. Attendance 21.

Texas A. & M. College

Calculation of Inductance of Overhead Wires, by O. M. Somers, student, and

General Transmission Line Equations for Steady State Conditions, by M. E. Horn, student. Pictures—"Power Transmission" and "The Induction Voltage Regulator." March 1. Attendance 27.

Neon Gas-Tube Lamp, by I. W. Corhart, student, and

Speed of Vision, by W. D. Neff, student. Pictures—"Making Mazda Lamps," "Light of a Race," "Liquid Air" and "Nature's Frozen Credits." March 15. Attendance 48.

Television, by E. F. Shawver and W. C. Rowland, students;

Ray-Photo, by A. D. Martin, student, and

The A. T. & T. System of Picture Transmission, by C. S. Robertson, student. Film—"Wizardy of Wireless." April 5. Attendance 41.

Radio-Activity, by C. C. Neighbors, student;

Electrical Units, by S. L. Moseley, student, and

Crystals and Piezo-Oscillators, by C. W. Jackson, student. Film "The Single Ridge." Election of officers. April 12. Attendance 50.

University of Texas

Television, by J. O. Perrine, American American Tel. & Tel. Co. March 21. Attendance 220.

Power Line Maintenance, by J. B. Robuck, student, and

Electric Refrigeration, by Chairman L. R. Bagwell. Plans for the coming Power Show discussed. April 11. Attendance 23.

University of Vermont

Lecture on and demonstration of a new oscillograph by Prof. L. P. Dickinson, Counselor. April 10. Attendance 21.

Radio Control of Trains, by L. M. Donahue, '30. Discussion of plans for the Student Convention in Troy. April 24. Attendance 13.

Virginia Polytechnic Institut

Modern Distributing Equipment, by F. C. Graves, Line Material Co. April 17. Attendance 17.

University of Virginia

Effect of Glazing on Insulators, by P. S. Beach, student, and *Airplane Compasses*, by H. R. Holt, student. Four reels on the construction and operation of electrical instruments. Refreshments. April 8. Attendance 35.

Washington University

Business meeting. April 13. Attendance 17.

Transformers, by F. H. Barrington, Chief Electrical Engr., Moloney Elec. Co. April 9. Attendance 19.

University of Washington

The Engineer in Business, by H. M. Gustafson, Sales Agent, General Electric Co. Business session. April 19. Attendance 21.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these Founder Societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES, APRIL 1-30, 1929

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

AIRCRAFT FLOAT DESIGN.

By Holden C. Richardson. N. Y., Ronald Press Co., 1928. (Ronald Aeronautic Series) 111 pp., illus., diagrs., tables, 9 x 6 in., cloth. $5.00.

A discussion of the fundamentals of float shapes and arrangements, intended to assist the designer in selecting a satisfactory arrangement and correct proportions, and in determining performance. The book presents material that has not been available heretofore in connected form.

DYNAMICS.

By A. S. Ramsey. Cambridge, Eng., University Press, 1929. N. Y., Macmillan Co., 259 pp., diagrs., tables, 9 x 6 in., cloth. 10s 6d.

Intended primarily for those preparing for a first honors examination in an English university and based upon lectures at Cambridge. Some knowledge of the calculus and elementary dynamics is assumed. Many worked and unworked examples are included.

E. T. Z. GESAMTINHALTSVERZEICHNIS; 1903 bis 1927 der Elektrotechnischen Zeitschrift, der bände 1 bis 18 des Archivs für Elektrotechnik, und der V. D. E.-Fachberichthefte 1926 und 1927. Edited by Franz Mooller. Berlin, Julius Springer, 1928. 653 pp., 12 x 9 in., paper. 24.-r. m.

The Electrotechnische Verein and the Verband Deutsche Elektrotechniker have joined in issuing this index, which covers the various publications of the societies from 1903 to 1927. With the index covering the first twenty-four years of the Elektrotechnische Zeitschrift which appeared in 1904, it is now possible to review quickly the important German literature on electrical engineering.

The index is both by author and subject. The subject portion is classified according to a simple, sensible plan. The type is of good size and the print clear.

ELECTRICAL TRANSMISSION AND DISTRIBUTION.

Edited by R. O. Kapp. v. 3 and v. 4, Switchgear. N. Y., Isaac Pitman & Sons, 1929. 2 v., illus., diagrs., tables, 8 x 5 in., cloth. $1.75 each.

These two volumes on switchgear form part of a treatise on electrical transmission and distribution by a number of English specialists. The work is descriptive, rather than theoretical, combining practical data with descriptions of commonly used switchboards and apparatus.

Part one discusses layouts and apparatus for high, average, and low tension a-c. switchgear and for d-c. switchgear. Part two discusses the care and operation of switchgear, ironclad switches for industrial and mining use, and protective systems for a-c. mains.

ELECTRICITY APPLIED TO MINING.

By H. Cotton. N. Y., Isaac Pitman & Sons, 1929. 625 pp., illus., plates, diagrs., 9 x 6 in., cloth. $10.00.

First discusses briefly the generation, transmission and distribution of electricity with particular reference to the problems of mining. The uses of electricity for driving fans, air compressors, pumps, coal cutters and conveyors, and for hauling, hoisting and lighting are then treated systematically in more detail. The author is in charge of the electrical department at University College, Nottingham.

ELEKTRIZITÄT IM HAUSE.

By F. Niethammer. Ber. u. Lpz., Walter de Gruyter & Co., 1929. 140 pp., illus., tables, 6 x 4 in., cloth. 1,50 r. m.

Describes briefly and in simple language the ways in which electricity is used in the home. Methods and apparatus for heating, lighting and cooking are described. Various forms of motors, cleaners, ironing and washing machines, telephones, radio receivers, etc., are illustrated and explained.

ENGINEERING ELECTRICITY.

By Ralph G. Hudson. 2d edition. N. Y., John Wiley & Sons, 1928. 214 pp., illus., diagrs., tables, 8 x 5 in., fabrikoid. $2.50.

A brief, yet rigorous course covering the general principles of electricity and magnetism most frequently applied in engineering practise. The book is primarily intended for students who are not specializing in electrical engineering and represents the instruction given junior and senior students of other branches of engineering at the Massachusetts Institute of Technology.

HISTORY OF MANUFACTURERS IN THE UNITED STATES, v. 1; 1607-1860.

By Victor S. Clark. N. Y., McGraw-Hill Book Co., 1929. Published for the Carnegie Institution of Washington. 607 pp., maps, 10 x 7 in., cloth. $15.00.

This is a revision of the volume published by the Carnegie Institution of Washington in 1916, which has been out of print for several years. It is now republished and will be extended later in the year by two volumes bringing the story down to the present time.

Dr. Clark has provided a basic work for students of manufacturing. It is strictly an economic history, not an account of

technology and mechanics, but students of the latter will nevertheless find it valuable and be helped further by the bibliographic footnotes. The book is a pioneer work, based on original material, which interprets the development, organization, and economic interactions of our manufacturing industry from its beginnings to the time when the nation changed from an agricultural to an industrial state.

HISTORY OF MATHEMATICAL NOTATIONS; v. 2, Notations mainly in higher mathematics.

By Florian Cajori. Chic., Open Court publishing Co., 1929. 367 pp., 9 x 6 in., cloth. $6.00.

The concluding volume of Dr. Cajori's history discusses the symbols of advanced arithmetic, algebra, and geometry, and of modern analysis. The two volumes contain almost all the symbols used down to the beginning of the nineteenth century and a representative selection of those occurring in recent writings. The amount of research that the work represents is extraordinary, and the history will be of great usefulness to mathematicians.

INDUSTRIAL DEVELOPMENT OF SEARLES LAKE BRINES.

By John E. Teeple. N. Y., Chemical Catalog Co., 1929. (Amer. Chemical Soc. Monograph series). 182 pp., illus., diagrs., 9 x 6 in., cloth. $3.00.

The author calls this a "short story of the application of research, technology and common sense to the development of a potash and borax business." Such histories of the infantile diseases of new industries are seldom written, and this graphic account of the early trials of one that finally succeeded will not only be welcome to those who are interested in potash, but may also be read with profit by young chemical engineers generally.

The equilibrium diagrams and data which fill about half the book cover 86 systems of from two to six components. They were prepared in connection with the development of the brines at Searles Lake.

JAHRBUCH DER HAFENBAUTECHNISCHEN GESELLSCHAFT. v. 10, 1927. Hamburg, Verlag der Hafenbautechnischen Gesellschaft, 1928. For sale by V. D. I. Verlag, Berlin. 222 pp., illus., diagrs. maps, 12 x 9 in., cloth. 30.-r. m.

Engineers interested in learning how German and Dutch harbors are equipped will find much information in this yearbook, which contains good descriptions of several important docks on the Rhine and in Holland. Particular attention is paid to machinery for handling coal and other bulk freight.

There are also extensive articles on the construction of the Rotterdam quay walls and the lighting and buoyage of the Elbe. A short account of the oil loading plants at the Chilean oil field is given. All the articles are profusely illustrated with drawings and photographs.

MANUFACTURE OF PULP AND PAPER, v. 5, 2d edition.

By Joint Executive Committee on Vocational Education representing the ...... Industry of the U. S. and Canada. N. Y., McGraw-Hill Book Co., 1929. Various paging, illus., diagrs., tables, 9 x 6 in., cloth. $6.00.

This volume is the concluding part of a work prepared under the direction of the Canadian Pulp and Paper Association and the Pulp and Paper Industry, which aims to provide a text-book covering the fundamentals of mathematics and science and the principles and practise of pulp and paper manufacture. The course of study is arranged definitely for home study.

About one-half of this volume is devoted to paper-making machines. The other topics are hand-made papers, tub sizing, paper finishing and testing, coated papers and paper-making details. The new edition has been thoroughly revised, several sections have been rewritten and some new topics have been added.

PHYSICAL PRINCIPLES OF WIRELESS.

By J. A. Ratcliffe. Lond., Mathuen & Co., 1929. 104 pp., diagrs., tables, 7 x 5 in., cloth. 2/6.

This small book, written by a physicist for physicists, is concerned with the physical principles on which radio is based, and omits engineering details. It discusses the electrical and acoustical phenomena concisely, yet clearly, and is especially intended for physicists who are not specialists in this subject.

RADIO OPERATING; Questions and Answers.

By Arthur R. Nilson and J. L. Hornung. 2d edition. N. Y., McGraw-Hill Book Co., 1929. 267 pp., illus., diagrs., tables, 8 x 6 in., cloth. $2.00.

Presents the essentials of radio operation in catechism form. Intended for use with "Practical Radio Telegraphy," by the same authors, and designed for students preparing for operator's licenses. This edition is revised in accordance with the U. S. Radio Act of 1927.

SIX-PLACE TABLES..with Explanatory Notes by Edward S. Allen.

3rd edition. N. Y., McGraw-Hill Book Co., 1929. 167 pp., 7 x 4 in., fabrikoid. $1.50.

These tables are clearly printed and the size is actually convenient for the pocket. The book contains the mathematical tables used regularly and continuously by engineers and engineering students, accurate to six places.

In the new edition the values of natural secants and cosecants have been added, and new tables for conversion between radians and degrees are included.

STATISTICAL MECHANICS..based on an Essay awarded the Adams Prize in the University of Cambridge, 1923-24.

By R. H. Fowler. Cambridge, Eng., University Press, 1929. N. Y., Macmillan Co., 570 pp., tables, 11 x 8 in., cloth. $10.50.

At the time (1924) when this work was begun, there was no recent exposition of the equilibrium theory of statistical mechanics, and the book is still the only one in English. The work aims to give a connected account of the theory, by the method developed by the author and Professor Darwin, with an exposition of its applications to physical and chemical problems. The book incorporates the results of the new mechanics, as well as those of classical mechanics.

STRENGTH OF MATERIALS.

By Arthur Morley. 7th edition. N. Y. Longmans, Green & Co., 1928. 569 pp., illus., diagrs., tables, 9 x 6 in., cloth. $4.20.

Covers the ground of the usual college courses in the subject, paying attention to several subjects, such as the strength of rotating disks and cylinders, and unstayed flat plates, the bending of curved bars and vibratory stresses, which are sometimes given scanty treatment. The changes from the sixth edition consist of added articles on the circular stress diagram and a rewritten statement about fatigue of metals.

THEORETICAL MECHANICS.

By Joseph S. Ames and Francis D. Murnaghan. Bost. & N. Y., Ginn & Co., 1929. (Engineering Series). 462 pp., 9 x 6 in., cloth. $5.00.

The purpose of this work is to privide students of physics, mathematics, and chemistry with a text and reference book which will correspond with the new view of theoretical mechanics which has resulted from recent advances in mathematical physics. It includes a systematic treatment of vector analysis, gyroscopic theory, wave motion, etc. The volume furnishes a foundation for advanced study of statistical mechanics, quantum dynamics, atomic theory, etc., and is adapted for class or private study.

THEORY OF HEAT.

By Thomas Preston. 4th edition. Lond. & N. Y., Macmillan Co., 1929. 836 pp., illus., diagrs., tables, 9 x 6 in., cloth. $8.50.

This comprehensive survey, from a historical point of view, of the development of the theory of heat, has been a favorite work since its appearance in 1894. The clear, connected account, illustrated by critical discussions of typical experiments, gives the reader a clear view of the subject, not limited by adherence to any arbitrary standards of curriculum or mathematical attainments.

This revision is chiefly in the experimental determinations of thermal data. The book has been brought up to date by careful additions and omissions.

WAVE MECHANICS; being one aspect of the New Quantum Theory.

By H. T. Flint. Lond., Methuen & Co., 1929. 117 pp., diagrs., 7 x 5 in., cloth. 3/6.

This little book aims to present in a reasonably simple manner an account of wave theory of mechanics as developed by de Broglie and Schroedinger. It is intended for those not in close contact with recent work in physics who wish to become familiar with this new method and its relation to existing theory. References to more advanced works are included.

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contributions from the societies and their individual members who are directly benefited.

Offices:—31 West 39th St., New York, N. Y.,—W. V. Brown, Manager.
1216 Engineering Bldg., 205 W. Wacker Drive, Chicago, Ill., A. K. Krauser, Manager.
57 Post St., San Francisco, Calif., N. D. Cook, Manager.

MEN AVAILABLE.—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to ***EMPLOYMENT SERVICE, 31 WEST 39th Street, New York City,*** *and should be received prior to the 15th day of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary: temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

POSITIONS OPEN

COMMERCIAL ENGINEER, with sufficient experience to plan and make complete proposals in the field for outdoor switching equipment and complete outdoor substations. Opportunity for engineer with proper experience. Apply by letter. Location, Pennsylvania. X-8203-C.

ENGINEER, 25-35, familiar with design of medium a-c. or d-c. motors. Apply by letter, stating age, training, experience and approximate salary expected. Location, Pennsylvania. X-8207-C.

ELECTRICAL ENGINEER, graduate, for motor and generator design work. Prefer man with test experience. Apply by letter. Location, Middle west. X-8291-C.

RECENT ELECTRICAL ENGINEERING GRADUATES, for work on communication apparatus testing equipment. Direct responsibility is assumed for the maintenance of this equipment. Opportunity is afforded for the practical application of a-c. and d-c. theory on complex circuits of most recent and highly developed electrical testing apparatus. Apply by letter. Location, Middle west. X-8237-R-398-C-S.

AGENTS REPRESENTATIVES

ELECTRICAL ENGINEER, sales and construction, 38, technical graduate. Seventeen years' experience, desirous of representing manufacturers who have no representative in Texas. Can give attention from sales through installation and maintenance. Specializes on complicated automatic apparatus, all or part time; has office and well acquainted with the trade. C-5887.

AGENCIES WANTED by manufacturer's representative maintaining office in New York City. Complete coverage of industrial plants in Metropolitan New York and adjacent territory assured. Electrical and mechanical lines preferred. B-6603.

MEN AVAILABLE

GRADUATE ELECTRICAL ENGINEER, desires position in office of consulting or contracting electrical engineer. Desirous of learning business with an opportunity of becoming a permanent part of firm. Has had four years' experience with public utilities, contracting electrical engineers and an oil corporation. Location, preferred, New York City or New Jersey. C-444.

TECHNICAL GRADUATE in electrical engineering, 30, single, desires position where there is a future for an ambitious man. Six years' test floor and service engineering experience with Westinghouse. Best of references. B-8985.

YOUNG MAN, 32, married, wishes to become associated with growing steel company or consulting firm. Practical experience in by-product coke works, blast-furnace and open hearth departments. Thoroughly familiar with foundry, machine shop, drafting practise. Educated in general engineering at leading technical school. Three years' general factory training, one year as plant engineer. Available upon one month's notice. C-5878.

ELECTRICAL ENGINEER, 24, single, six months' general testing; two and a half years' design of rural and city distribution. Desires connection in a distribution department with a future. Available on reasonable notice. Location, preferred, East. C-5454.

DISTRIBUTION ENGINEER, 31, married, graduate E. E. Eight years' experience in distribution construction and engineering. Now employed as division distribution engineer of large utility. Desires permanent position with large responsibilities and future. B-8214.

ELECTRICAL ENGINEER, single, 41. Experienced in public utility work, buying, selling, investigating and managing. Has had charge of important construction and engineering projects in this country and abroad, including hydroelectric power plants, transmission lines, substations, railway electrification, etc. Has made reports on projects. Speaks Spanish. C-5846.

DOCTOR IN ELECTRICAL ENGINEERING. Graduate of foreign university, American born but speaking little English, although under standing it, seeks connection with engineering firm or consulting engineer as draftsman computor. C-5830.

ELECTRICAL ENGINEER, 31, ten years' experience; two years complete wiring plans, specifications, engineering correspondence, for light, power, signals on theaters, hotels, office buildings, loft buildings, clubs, etc.; one year with electrical contractor on large buildings; desires permanent connection anywhere as designing engineer with architect or estimating engineer with contractor. B-4217.

GRADUATE, 22, single, who has obtained a B. S. in Electrical Engineering, desires a position with a company doing engineering work, preferably electrical. Ready to do anything to get ahead. Location, New England or New York. C-5872.

ELECTRICAL ENGINEER, 30, married, 1922 graduate E. E., Cornell University. Seven years' experience in electrical layout, construction, maintenance and supervision in nationally known industrial concern. Desires position with industrial concern, consulting engineer or construction company. C-5929.

PROFESSOR OF ELECTRICAL ENGINEERING. Head of Department in a state institution would like a change in schools if opportunity and larger income are available. Excellent technical training as well as practical experience. Especially successful in department organization and development. Writer of technical articles and member of honorary and professional societies and state engineering board and committees. B-3253.

ELECTRICAL ENGINEER AND DESIGNER, 38. Ten years' experience in development of a-c. motors, generators and transformers with leading manufacturers. Capable of handling both the electrical and mechanical design of new lines of a-c. machinery and having also valuable selling experience. Available immediately. B-8592.

ELECTRICAL ENGINEER, B. S., 28, desires connection with concern doing business in Spain or South America. Three years' practical experience in power plants, testing, transmission and distribution with two large public utility companies. Speaks Spanish and French fluently; knowledge of Portuguese. Available to travel on short notice. C-5935.

ELECTRICAL ENGINEER, 32, married. Eight years' experience with public utilities covering construction, design, estimating and general engineering work on power houses and substations. East or Middlewest preferred. C-5925.

ASSISTANT PROFESSOR OF ELECTRICAL ENGINEERING, 39, married. B. S. and E. E. degrees, General Electric Test and nine years' experience in state universities, desires position as head of department or professor of electrical engineering in a first-class university or engineering school. West preferred. C-4403.

ELECTRICAL ENGINEER, 36, single, B. S. in E. E.; seven years' public utility experience in laboratory and field testing of power and industrial equipment, protective relays and meters. Considerable oscillographic experience. Desires position with engineering or industrial firm. No preference as to location. C-5713.

ELECTRICAL ENGINEER, technically trained, mature judgment, pleasing personality. Eleven years' experience with large industrial plants such as steel and paper mills, construction, maintenance, repairs, including redesigning, rewinding of armatures, stators, transformers; design, construction of special automatic controls for specific duty. Four years' experience, large custom repair shop. Excellent references. De-

sires position with industrial concern or custom repair shop. C-5916.

ELECTRICAL ENGINEER, university graduate, 36. Wide knowledge of electrification including generation, substations, distribution, motor application, control, lighting, etc., as applied to mining, cement mills and other industries. Experience covers estimates, design and layout, construction and maintenance. Desires to correspond with large industrial concern requiring the services of a man of above qualifications. B-9143.

ELECTRICAL ENGINEER, 25, B. S. in E. E. Experience in special investigations, tests, calculations, designing of special equipment, devising methods of test, report writing, etc., with public utility. Desires engineering or teaching position with opportunity for advancement. Available on reasonable notice. C-5957.

GRADUATE ELECTRICAL ENGINEER, with degree of E. E., with wide experience in testing, construction, operating, investigation, sales and managing. Has been in charge of hydroelectric systems aggregating 250,000 kv-a., operating on heads of 1700 ft. and transmitting at 110,000 volts. Capable of managing a property or group of properties and putting them on a paying basis. Now employed. Location, immaterial. C-4222.

CONNECTION LEADING TO MANAGERIAL OR EXECUTIVE POSITION, desired by employed electrical engineer with successful record in organizing and developing nationally known engineering service. Other experience includes direction maintenance for large public utility and eight years erection and service shop direction for one of larger electrical manufacturers. Married. Salary $8000 a year. B-122.

ELECTRICAL ENGINEER. One year engineering course, four years' apprenticeship with large manufacturer of electrical equipment, one year test, erection of switchgear, three years' course for E. E. degree. Since graduation, two years construction, then electrical designer for utility company. Five years supervision of electrical design, tests, construction for coal company. Familiar with automatic controls. West preferred. C-5958.

SALES ENGINEER, 42, technical education, twelve years' experience in sales engineering, sales management. Lines handled have been electrical apparatus and electric power equipment. Married, good health and habits, intensive worker. Desires position, preferably in East, as sales manager of electrical manufacturing house. Would consider attractive proposition to represent in sales capacity. C-5966.

ELECTRICAL ENGINEER, 34, single, 1917 graduate. General Electric Test and Central Station Engineering Department experience. At present in charge of a group handling system relaying and apparatus specifications for large public utility company. Prefer East or Southeast. Available on one month's notice. C-2591.

INSTRUCTOR IN ELECTRICAL ENGINEERING, 36, married, college graduate; also graduate of U. S. Navy Electrical School and U. S. Navy Radio School. Ten years' experience teaching electrical engineering and radio. Successful teacher and organizer. Member of honorary and professional societies. Desires position as assistant professor in electrical engineering or would consider research work in engineering experiment station. C-5885.

ELECTRICAL ENGINEERING GRADUATE, single, 23. Desires position connected with the design, construction or maintenance of transmission systems. Future prospects considered more important than initial salary. Best references. Available on one month's notice. Location preferred, South or Middle west. C-5967.

ELECTRICAL ENGINEER, 38, married. A. B. degree, DePauw University, M. E. and E. E. degrees, Cornell University. Eight years' public utility experience; also power and meter experience. General Manager of telephone company for four years. Salary, $300 a month. Middle west preferred. C-5979.

ELECTRICAL ENGINEER, M. S. and E. E., married. Twelve years' experience, including teaching, university and industrial research, operating department of large utility. Desires position as research and development engineer with an industrial or engineer on interconnection problems with a utility. Location, immaterial. Available, two weeks. B-7223.

ELECTRICAL ENGINEER, 29, married. Graduate B. S. in E. E., now employed by one of the largest manufacturing companies. Seven years' experience including student course and Central Station Sales at factory and district office. Desires sales or purchasing electrical equipment with progressive organization. Location preferred, New York City or vicinity. C-3802.

MEMBERSHIP—Applications, Elections, Transfers, Etc.

APPLICATIONS FOR TRANSFER

The Board of Examiners, at its meeting of May 15, 1929, recommended the following members for transfer to the grades of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grade of Fellow

BYNG, EDWARD S., Managing Director, Standard Telephones and Cables, Ltd., London, England.
CURRIE, HARRY A., Electrical Engineer, New York Central Railroad Co., New York, N. Y.
NESBIT, WILLIAM, Northeastern Engg. Mgr., Westinghouse Elec. & Mfg. Co., New York.
VANDERSLUIS, WARREN M., Electrical Engineer, Illinois Central Railroad, Chicago, Ill.

To Grade of Member

BOECK, CHRISTIAN F., Communication Engineer, Bell Telephone Labs., New York.
BULLER, FRANCIS H., Electrical Engineer, General Electric Co., Schenectady, N. Y.
CHARLTON, JOHN R., Division Plant Engr., American Tel. & Tel. Co., St. Louis, Mo.
CREASEY, JOHN W., District Plant Supt., American Tel. & Tel. Co., Dallas, Texas.
CURDTS, EDWARD B., Supt., Light and Power, Carolina Division, Va. Elec. & Pr. Co., Roanoke Rapids, N. C.
DUFFIN, CHARLES G., Foreign Wire Relations Engr., Pacific Tel. & Tel. Co., Seattle, Wash.
EDDY, WILTON N., Director of Elec. Research Lab., Simplex Wire & Cable Co., Boston, Mass.
FISHER, WILLIAM B., Electrical Supt., Stone & Webster Engg. Corp., Boston, Mass.
FLATH, EARL H., Dean of Engg., Southern Methodist University, Dallas, Texas.
GIBBONS, EDWARD J., Operating Engineer, Halcomb Steel Co., Syracuse, N. Y.
GRZYBOWSKI, JOHN M., Research Elec. Engr., Westinghouse Elec. & Mfg., E. Pittsburgh, Pa.
GUSTAFSON, CLIFFORD W., Chief Engr., Mutual Fire Prevention Bureau, Chicago, Ill.
HARZA, CARL W., Asst. Supt., Meter Installation and Inspection, The Detroit Edison Co., Detroit, Michigan.
HENDERSON, EBERT W., Design Engr., Reliance Elec. & Engg. Corp., Cleveland, Ohio.
HUTCHINS, CHARLES C., Elec. Engr., Elliott Co., Ridgway, Pa.
JONES, WARREN C., Telephone Engr., Bell Tel. Labs., New York.
KUTNER, SIDNEY D., Asst. Engr., N. Y. Central R. R. Co., New York.
LYMAN, OLIVER B., Vice-President, Utilities Equipment Corp., San Francisco, Calif.
MARVIN, RICHARD H., Research Fellow in Elec. Engg., Johns Hopkins University, Baltimore, Md.
MAXSON, R. H., Electrical Engr., Burdick Corp., Milton, Wis.
MELVILLE, SAMUEL P., Designing Elec. Engr., Stone & Webster Engg. Corp., Boston, Mass.
MENDENHALL, IVAN S., Engineer, Detroit Edison Co., Detroit, Michigan.
MOWRY, HARRY W., Installation Development Engr., Western Electric Co., Inc., New York, N. Y.
REED, LINWOOD E., Junior Elec. Engr., Potomac Electric Power Co., Washington, D. C.
RICHARDS, LEE M., Elec. Engr., Emerson Elec. Co., St. Louis, Mo.
RICHTER, HENRY, General Engr., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
SAWYER, LEON G., Electrical Engineer, 50 Church St., New York.
SCHOFIELD, ALBERT, Sales Engineer, Ferranti Elec. Ltd., Toronto, Ont., Canada.
SEABURG, HAROLD, Chief Elec. Engr., United Fruit Co., Banes, Oriente, Cuba.
SHIPEK, ADOLPH, Design Engr., Puget Sound Pr. & Lt. Co., Seattle, Wash.
SMITH, PAUL C., Instructor of Elec. Engg., University of Akron, Akron, Ohio.
SMITH, REGINALD S., General Foreman, N. Y. Edison Co., New York.
SNYDER, CHARLES C., Engr., Dept. of Water & Power, Los Angeles, Calif.
VAN HOUTEN, LESLIE P., Technical Employee, American Tel. & Tel. Co., New York.
WUNSCH, FELIX, Technical Advisor, Leeds & Northrup Co., Philadelphia, Pa.
YOUTZ, J. P., Lighting Service Bureau, Rio de Janiero, Brazil, S. A.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a higher grade than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before June 30, 1929.

Andriessen, A., Union Gas & Electric Co., Cincinnati, Ohio
Banes, C. R., (Member), E. L. Phillips & Co., New York, N. Y.
Barkey, I. H., General Talking Pictures, New York, N. Y.
Beaman, W. M., Texas Creosoting Co., Dallas, Tex.
Bishop, G. E., Southern California Edison Co., Los Angeles, Calif.
Bonelli, J., F. A. D. Andrea Co., Long Island City, N. Y.
Brewer, R., Jr., Emerson Electric Co., St. Louis, Mo.
Brosnan, T. J., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Burris, C. A., Yonkers Electric Light & Power Co., Yonkers, N. Y.
Caldwell, S. E., Portland Electric Power Co., Portland, Ore.

Chassinat, M., 142 West 78th St., New York, N. Y.
Chen, T. H., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Clifford, W. R., Layne & Bowler, Los Angeles, Calif.
Cooper, V. E., Union Gas & Electric Co., Cincinnati, Ohio
Crabtree, K. G., University of Maine, Orono, Me.
Darcy, H. B., (Member), Electrical Equipment & Construction Co., Houston, Tex.
Davidson, D. H., Pacific Tel. & Tel. Co., Sacramento, Calif.
DeKeyser, J. F., (Member), Acme-International X-Ray Co., Chicago, Ill.
Dickinson, J., Philadelphia Coke Co., Philadelphia, Pa.
Dillard, G. B., Commonwealth Edison Co., Chicago, Ill.
Dougherty, P. B., Indiana General Service Co., Marion, Ind.
Dunkle, A. V., Sullivan Mining Co., Kellogg, Idaho
Edwards, J. B., New York Telephone Co., Brooklyn, N. Y.
Elerick, A. G., Stone & Webster, Inc., Seattle, Wash.
Elliott, J. O., Union Gas & Electric Co., Cincinnati, Ohio
Ellis, C. A., Warren Telechron Co., Ashland, Mass.
Elmer, W. B., Edison Electric Illuminating Co. of Boston, Roxbury, Mass.
Felcher, E. H., Underwriters Association, Reading, Pa.
Garner, R. C., R. C. A. Photophone Inc., New York, N. Y.
Goodnow, A. C., (Member), General Electric Co., Lynn, Mass.
Gray, C. H. G., Bell Telephone Laboratories, Inc., New York, N. Y.
Gring, M. H., Pennsylvania Power & Light Co., Pottsville, Pa.
Hauschild, J. W., United Engineers & Constructors, Inc., Philadelphia, Pa.
Hoffmann, E. A., Johnson Electric Supply Co., Cincinnati, Ohio
Hoover, I. M., Montpelier Municipal Plant, Montpelier, Ohio
Houchens, J. M., Ahrens Trade School, Louisville, Ky.
Hulan, A. G., R. C. A. Photophone Inc., New York, N. Y.
Jones, L., University of Pittsburgh, Pittsburgh, Pa.
Jopp, J. M., Manitoba Paper Co., Pine Falls, Manitoba, Can.
Kantenberger, W. J., Electrical Engineers Equipment Co., Melrose Park, Ill.
Kidder, A. H., Philadelphia Electric Co., Philadelphia, Pa.
Kilbourne, C. E., General Electric Co., Schenectady, N. Y.
Kirkwood, R. H., Pacific Tel. & Tel. Co., San Francisco, Calif.
Klintworth, G., Commonwealth Edison Co., Chicago, Ill.
Kronmiller, C. W., General Electric Co., Fort Wayne, Ind.
Lakas, J. M., Cornell University, Ithaca, N. Y.
Leamy, J. M., (Member), Spooner & Merrill, Inc., Chicago, Ill.
Legare, T. O. R., General Electric Co., Schenectady, N. Y.
Leicht, J. H., New York Telephone Co., Mt. Vernon, N. Y.
Leonnig, L. J., General Railway Signal Co., Rochester, N. Y.
Lewis, H. R., Commonwealth Edison Co., Chicago, Ill.
Loeffler, B. T., Indiana Bell Telephone Co., South Bend, Ind.
Lusk, R. R., Kansas City Power & Light Co., Kansas City, Mo.
Martin, H. G., Jr., (Member), 545 Atlantic Ave., Brooklyn, N. Y.
Matson, I. M., Electrical Prod. Corp. of Utah, Salt Lake City, Utah
McCarter, H. A., Standard Oil Co. of California, Whittier, Calif.
McClure, J. B., General Electric Co., Schenectady, N. Y.
Milburn, W. H., Bailey Meter Co., Cleveland, Ohio
Millard, T. O., General Electric Co., Chicago, Ill.
Mortimer, H. E., Stone & Webster, Inc., Boston, Mass.
Muncy, V. E., Ohio Mechanics Institute, Cincinnati, Ohio
Neubauer, E. O., Illinois Bell Telephone Co., Chicago, Ill.
Nichols, E. B., (Member), Victor Talking Machine Co., Camden, N. J.
Noll, G. B., Electric League of Erie, Erie, Pa.
Northrop, M. G., Cornell University, Ithaca, N. Y.
Nuber, F. J., American Electric Co., Inc., Chicago, Ill.
Oram, J., (Member), Dallas Power & Light Co., Dallas, Tex.
Parker, O. B., Pacent Electric Co., New York, N. Y.
Phillips, L. A., Pennsylvania Power & Light Co., Hazleton, Pa.
Pierson, M. F., Pierson Electric Shop, Knoxville, Ill.
Quinn, J. L., University of Santa Clara, Santa Clara, Calif.
Radler, R. W., Union Gas & Electric Co., Cincinnati, Ohio
Rall, A. A., Kansas City Power & Light Co., Kansas City, Mo.
Rasmussen, P. J., Cushman Lumber Co., Cushman, Ore.
Redding, J. A., General Electric Co., Schenectady, N. Y.
Richardson, W. J. (Member), Palace Theatre, South Bend, Ind.
Roof, B. J., Union Gas & Electric Co., Cincinnati, Ohio
Rose, M. M., Furest-Friedman Co., Cleveland, Ohio
Ross, R. D., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Ruehlin, W. H., Electric Auto-Lite Co., Toledo, Ohio
Ruzicka, C. J., Standard Oil Co. of California, Whittier, Calif.
Seltzer, S., Emerson Electric Mfg. Co., St. Louis, Mo.
Seyler, H. F. L. J., Consolidated Gas, Electric Light & Power Co., Baltimore, Md.
Shedlock, E. T., Coast Artillery Corps, U. S. Army, Fort H. G. Wright, New York
Sparks, W. S., Western Union Tel. Co., New York, N. Y.
Starr, E. C., (Member), Oregon State College, Corvallis, Ore.
Stupak, J. L., Weston Electrical Instrument Corp., Newark, N. J.
Sveen, E. A., French Battery Co., Madison, Wis.
Teckoe, J. E., (Member), Hydro-Electric Commission of Niagara Falls, Niagara Falls, Ont., Can.
Taff, J. C., State Trade School, Middletown, Conn.
Thomson, H. W., Southern California Edison Co., Los Angeles, Calif.
Thomson, J. F. P., Southern Sierras Power Co., El Centro, Calif.
Tilson, H. M., Department of Public Works, Sacramento, Calif.
Vogele, A. J., (Member), Commonwealth Edison Co., Chicago, Ill.
Wallace, A. M., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Walter, F. W., Postal Telegraph & Cable Co., New York, N. Y.
Warner, E. S., Hudson Coal Co., Scranton, Pa.
Wild, A. A., Jr., Southwestern Bell Tel. Co., Oklahoma City, Okla.
Winder, I. T., Wickwire Spencer Steel Corp., Palmer, Mass.
Woodworth, C. O., Public Service Co. of Colo., Denver, Colo.
Zangler, R. M., Hastings Wire & Cable Co., Hastings, N. Y.
Total 101.

Foreign

Gulati, P. C., Hydro Electric Branch, Kangra, Punjab, India
Kitagawa, K., Sumitomo Electric Wire & Cable Works, Ltd., Osaka, Japan
Lu, T. Y., Ho-Zan Bank, Main St., Changchow, Kiangsu, China
Page, A., (Fellow), Central Electricity Board, London, Eng.
Williams, C. S., (Member), Cerro de Pasco Copper Corp., Oroya, Peru, So. America
Total 5.

STUDENTS ENROLLED IN MAY

Abeles, I. Meyer, University of Pennsylvania
Adams, Bennett R., Jr., Georgia School of Tech.
Adamson, Ralph T., University of Nevada
Aeberli, William A., University of Pittsburgh
Alusic, Joseph, University of Wisconsin
Andres, Robert R., University of Notre Dame
Angst, Derrill C., University of Nevada
Arehart, Oscar M., University of Louisville
Atwood, Byron E., Kansas State Agricultural College
Augustus, Lee M., University of Michigan
Beling, Geert D., Marquette University
Belvin, Charles H., Jr., North Carolina State College
Berg, George E., Jr., University of Kansas
Billhartz, W. H., University of Pittsburgh
Bliss, Warren H., Michigan State College
Bodnar, Arthur A., University of Pittsburgh
Bohne, Ray K., University of Utah
Boley, Harold C., Kansas State Agricultural College
Bolze, Joseph N., Brooklyn Polytechnic Institute
Bornemann, Fred E., Rensselaer Polytechnic Inst.
Bottonari, Samuel A., Carnegie Institute of Tech.
Bratton, Edward W., University of Michigan
Bredehoft, Elmer H., Kansas State Agricultural College
Brunk, Ralph E., Kansas State Agricultural College
Brusa, Armand L., Rensselaer Polytechnic Inst.
Bruse, Carl B., Purdue University
Bruun, Lorentz A., Oregon Institute of Tech.
Burke, Bryon R., University of Colorado
Buttram, Henry J., Georgia School of Technology
Castiglia, Frank H., New York University
Chapman, James F., University of Nebraska
Clark, George G., The Municipal University of Akron
Clark, Paul L., Montana State College
Clarkson, William G., University of Toronto
Clayton, John T., Ohio Northern University
Conley, J. Joseph, University of Notre Dame
Conroy, Edward G., University of Notre Dame
Conway, Ralph W., University of Cincinnati
Cook, Harry E., University of Nebraska
Cook, Lewis, C., Michigan State College
Corn, Lawrence H., University of Pennsylvania
Creighton, Robert R., University of Pennsylvania
Crews, Ray F., Oregon Institute of Technology
Darling, Horace, Brown University
De Journett, Homer V., West Virginia University
Denman, Walter R., Kansas State Agricultural College
Deschner, Fabian S., South Dakota State College
Detwiler, Frank T., Brooklyn Polytechnic Inst.
Diffenderfer, Samuel F., Rensselaer Polytechnic Institute
Dodson, Whitney E., Ohio Northern University
Dolan, John M., University of Notre Dame
Drury, Cecil MacB., University of Southern California
Dysart, Ronald R., University of Nebraska
Edwards, William H., University of Toronto
Elfman, Bernard L., Pennsylvania State College
Emurian, Albert D., University of Pennsylvania
Fay, Joseph, University of Notre Dame
Fife, William H., University of Cincinnati
Fisher, Lawrence T., Oregon State College
Fitzsimmons, Albert W., University of Cincinnati
Flory, Leslie E., University of Kansas

Fraser, William S., University of British Columbia
Freeman, Robert L., Stanford University
Garrett, William A., University of Denver
Gaskell, Joe, Engineering School of Milwaukee
Gerstein, Leo H., University of Nebraska
Gilchrist, Fred W., Ohio State University
Gilroy, John W., University of Southern Calif.
Googins, Danforth M., Univ. of New Hampshire
Graham, Henry U., University of Pennsylvania
Griffin, Lowell L., Engg. School of Milwaukee
Gueffroy, Russell S., Oregon Institute of Tech.
Gurley, Glenwood H., University of Kansas
Gustanoff, Abe L., University of Washington
Hammond, Merle W., University of Kansas
Harmony, Harold A., University of Washington
Hartshorn, Rolfe, I., Ohio Northern University
Hasley, Andrew D., University of Michigan
Hauser, Herman T., University of California
Helgesson, Leonard, Oregon State College
Henderson, Valtin L., University of Toronto
Hensley, Marvin S., University of Kansas
Holmes, John R., McGill University
Hoyt, Philip F., University of Nebraska
Hughes, Cyril A., University of Notre Dame
Hunt, Spencer, University of Southern California
Iglehart, Ferdinand C., University of Pennsylvania
Jacobson, Leo, Brown University
Jautz, Gilbert J., University of Wisconsin
Jensen, Walter H., University of Nevada
Jochem, Theodore B., Marquette University
Johansen, Harold C., Purdue University
Jones, Bernard A., University of Pittsburgh
Jones, Daniel E., North Carolina State College
Jones, Harold W., Clarkson College of Technology
Karr, J. Harold, Kansas State Agricultural College
Kawaguchi, Tadashi, Stanford University
Kelly, Richard E., Carnegie Institute of Tech.
Kirkwood, Loren R., Kansas State Agricultural College
Kling, John J., Michigan State College
Kohler, Ernest Jr., Massachusetts Inst. of Tech.
Lampson, Curtis W., South Dakota State College
Lantry, Tom, University of Notre Dame
Lewis, Rodney C., University of Southern Calif.
Lockner, Sidney P., University of Pittsburgh
Lunn, Edward O., University of British Columbia
Lydick, Lawrence N., Kansas State Agricultural College
Magers, Oliver N., Kansas University
Markle, Bruce H., Kansas State Agricultural College
Martinoff, Vcěvolod M., University of Toronto
Martz, Merrill J., University of Colorado
Millen, William I., Jr., Marquette University
Miller, Henry D., University of Nebraska
Mitcham, John D., Texas A. & M. College
Nartker, Leo J., University of Cincinnati
Nelson, Albert H., University of Southern Calif.
Nelson, Charles H., University of Pennsylvania
Nickerson, Allan F., Brown University
Nonken, Gordon O., Kansas State Agricultural College
Orth, Richard T., Purdue University
Pankow, Edmund G., Ohio Northern University
Parker, Nelson H., Jr., Goergia School of Tech.
Parker, William H., Jr., Mass. Inst. of Tech.
Paulson, William D., University of Colorado
Perry, Herbert J., University of Notre Dame
Peters, Leo R., Ohio State University
Peterson, Reuben, Iowa State College
Phillips, Albert F., Carnegie Institute of Tech.
Pickett, George E., North Carolina State College
Pinkerton, Frank, Georgia School of Technology
Podlaski, Charles G., University of Notre Dame
Powell, Wayne M., University of Kansas
Powers, William F., Brooklyn Polytechnic Inst.
Pryor, Philip L., Iowa State College
Reed, Fred J., University of Pittsburgh
Roland, Stanley W., Michigan State College
Roth, William F., University of Pennsylvania
Rowe, Edward L., Jr., University of Vermont
Russell, Stephen S., University of Cincinnati
Sallemi, John B., University of Illinois
Schmid, J. Leonhard, University of Pennsylvania
Schmidt, Elmer C., University of Illinois
Schumacher, Lawrence R., South Dakota State College
Sento, Tadashi, Tokyo Imperial University
Sewell, Seymour W., Lewis Institute
Sheehy, Joseph J., Marquette University
Shen, Pao-Guay, Harvard University
Shoemaker, Malcolm G., University of Nebraska
Simon, Andrew, Jr., Purdue University
Smith, Harold A., Brown University
Smith, Harold W., University of New Hampshire
Smith, Newbern, University of Pennsylvania
Smith, W. Morden, Michigan State College
Spies, John F., Washington University
Sproul, Robert R., Brown University
Steele, Arlo L., Kansas State Agricultural College
Stiles, Merrill R., South Dakota State College
Strasbourger, Julius C., University of Cincinnati
Stuttle, Alfred F., University of Illinois
Swyter, Carl, South Dakota State College
Tanner, Raymond E., Brown University
Taylor, Clyde O., University of Cincinnati
Tebo, Gordon B., University of Toronto
Tobe, Samuel S., Brown University
Townsend, Paul H., Northeastern University
Tsao, Tsen-Cha, Harvard University
Tynan, Andrew G., University of Pennsylvania
Vanderlippe, Richard A., University of Nebraska
Varga, George E., University of Pittsburgh
Viola, Albert G., University of Illinois
Verd, Paul H., University of Washington
Walsh, J. A., University of Nevada
Weber, Joe, University of Cincinnati
Weddington, William W., Georgia School of Tech.
Werner, Lawrence H., Jr., University of Detroit
Westendarp, Franz G., University of Pennsylvania
Wherry, W. J., University of Pittsburgh
Whitney, Herbert W., Texas A. & M. College
Wiegreffe, John L., University of Illinois
Wilson, Lee H., Bucknell University
Wood, Wallace J., Pennsylvania State College
Woodland, Harold E., University of British Columbia
Ziochovski, Edward F., Rhode Island State College

Total 183.

Officers of the A. I. E. E., 1928-1929

PRESIDENT
(Term expires July 31, 1929)
R. F. SCHUCHARDT

JUNIOR PAST PRESIDENTS
(Term expires July 31, 1929) C. C. CHESNEY
(Term expires July 31, 1930) BANCROFT GHERARDI

VICE-PRESIDENTS
(Terms expire July 31, 1929)
O. J. FERGUSON (District No. 6)
E. R. NORTHMORE (District No. 8)
J. L. BEAVER (District No. 2)
A. B. COOPER (District No. 10)
C. O. BICKELHAUPT (District No. 4)

(Terms expire July 31, 1930)
E. B. MERRIAM (District No. 1)
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Choke Coils and Fuse Mountings.—Bulletin 'F" describes a new line of outdoor reinforced choke coils, fuse mountings and combined choke coils and fuse mountings. The Champion Switch Company, Kenova, West Va.

Motor Starter.—Bulletin 482, 4 pp. Describes Condit Type A-30 air motor starter, made in capacities of 20 horsepower or less. Condit Electrical Manufacturing Corporation, Boston, Mass.

Automatic Stations.—Bulletin GEA-90D, 32 pp. Describes G-E automatic installations to January 1, 1929. General Electric Company, Schenectady, N. Y.

Low-Voltage A-C. Networks.—GED—265, 44 pp. This publication is a reprint of articles on the subject of low-voltage a-c. networks by D. K. Blake appearing in 1928 and 1929 issues of *General Electric Review*. General Electric Company, Schenectady, N. Y.

Pyrometers.—Supplement 400-1, 4 pp. Describes type FD pyrometer outfits consisting of a 4 in. instrument, a thermocouple and leads. The device is used on typecasting machines to determine the temperature of the metal. The Roller-Smith Company, 12 Park Place, New York.

Arc Welding.—The Lincoln Electric Company, Cleveland, Ohio, has issued twice each month supplement sheets on various phases of the application of welding as applied to the manufacturing of machinery and equipment. A new monthly issue is devoted to "Studies in Structural Welding" showing the latest application of welding to structural work.

Deion Circuit Breakers.—S. P. 1836, 50 pp., entitled The New Deion Circuit Breakers. This publication consists of a series of A. I. E. E. papers, together with *Electrical World* and *Electric Journal* articles which have been published recently covering the theory and development of the deion circuit breaker and field tests which have been applied to it. An A. I. E. E. paper presented at the summer convention in June 1928 on Extinction of an A. C. Arc by Dr. J. Slepian, inventor of the deion breaker, is also included. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Electric Controls.—Catalog 29. A publication of several hundred pages devoted to "Bull Dog" electric controls, including safety switches, knife switches, light and power panelboards and cabinets, metering panelboards and cabinets, and safety switchboards. Bull Dog Electric Products Company, 7610 Jos. Campau Avenue, Detroit, Mich.

Transformer Performance.—Bulletin 164, 12 pp. Discusses the losses which occur in distribution and power transformers, the method of making tests on transformers to determine their acceptability and the calculations of operating characteristics from the test data. Wagner Electric Corporation, 6400 Plymouth Street, St. Louis, Mo.

NOTES OF THE INDUSTRY

The Champion Switch Company, Kenova, West Va., has appointed George L. Carlisle vice-president and general manager. Mr. Carlisle has had wide experience in the public utility field, having spent nine years with the West Penn Power Company. Prior to that connection he was engaged in consulting engineering work, principally in connection with mining developments.

First Double-Deck Compound Turbine-Generators.—Several unusual or new features will be incorporated in two steam turbine generators which are to be added to the generating facilities of the Pacific Gas and Electric Company, San Francisco. The two machines, of General Electric manufacture, each rated at 50,000 kilowatts, will be the first of the new "double-deck compound" type, will be the first high-pressure turbines on the Pacific Coast, and will be fueled with natural gas piped from a source 240 miles away.

Illinois Electric Porcelain Appoints J. W. Ward.—The Illinois Electric Porcelain Company, Macomb, Illinois, announces that J. W. Ward, for the past six years general superintendent of the Porcelain Insulator Corporation, Lima, N. Y., and previously, in the same capacity with the Westinghouse plant at Derry, Pa., is now associated with its organization and will give the Illinois Company the benefit of his long experience in the manufacture of high-tension insulators.

Solderless Connector.—The Penn-Union Electric Corporation, Erie, Penn., is manufacturing a solderless connector with a locking action, which holds tight permanently, for use on high-tension lines. In the use of the connector a lock-nut is turned onto the yoke, a split wedge-shaped sleeve forces the body of the connector tightly against the main conductor. At the same time the sleeve clamps tighter to the branch, equalizing the pressure on the main and branch conductors. The conductors are made in a complete line and a variety of types are carried in stock for prompt delivery in combinations and sizes for every electrical requirement.

New Oil Circuit Breakers by Delta-Star.—The Delta-Star Electric Company, Chicago, has announced a new line of outdoor oil circuit-breakers in voltages from 37 kv. to 73 kv. inclusive. Reliability and ruggedness to withstand repeated punishment has been the key-note throughout the entire design. They are of the double gas isolated type with special oil retractors to prevent oil throw. Among the noteworthy points are high flashover, bushings of the oil or compound type, multiple ratio current transformers, hot dipped galvanized support frames, gas and oil proof terminal blocks, and a closing mechanism of the trip free any position type.

A thorough oscillographic study given to the relief of dynamic stresses of the moving parts, resulted in a breaker having a maximum contact velocity with minimum dynamic stresses, and with safety factors for these moving mechanical parts far in excess of that generally considered satisfactory. Special steel alloys having shock resisting and fatigue qualities are used throughout.

Allis-Chalmers Receives Large Orders.—Contracts have been placed with the Allis-Chalmers Manufacturing Company covering equipment for the extension of the Waukegan Generating Station of the Public Service Company of Northern Illinois, Sargent & Lundy, Incorporated, Engineers, including a 65,000 kw. tandem steam turbine unit with condenser, circulating water and condensate pumps. This is the fourth unit for this station. The first was rated 25,000 kw. and was installed in 1923. A 35,000 kw. unit was installed in 1925 and a 50,000 kw. in 1927, all of the Allis-Chalmers make. Unit No. 4 will be rated 65,000 kw. tandem compound with one generator and will be similar to the 50,000 kw. unit No. 3 except it will be arranged for boiler reheat. The operating conditions are 600 lbs. steam pressure, 725° F. total steam temperature and 29 in. vacuum referred. The electrical end is 60 cycle, 3 phase, 12,000 volts, and includes a 250 volt direct connected exciter.

An order has also been received from the Milwaukee Electric Railway & Light Company for a steam turbine unit to be installed in the Lakeside Power Station. This unit is rated 60,000 kw. and will be of the straight reaction, single-cylinder, single-generator type with direct connected exciter. The turbine is designed for a normal operating steam pressure of 290 lb. gauge and a temperature of 700° F. The electrical characteristics of the unit are 13,800 volts, 60 cycles, 3 phase, and exciter has a capacity of 200 kw. The unit will operate at 1800 rev. per min.

JOURNAL OF THE A. I. E. E

DEVOTED TO THE ADVANCEMENT OF THE THEORY AND PRACTISE OF ELECTRICAL ENGINEERING AND THE ALLIED ARTS AND SCIENCES

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Vol. XLVIII JULY, 1929 Number 7

Institute Progress

THE 1929 Summer Convention has now passed into history. It has marked another milestone in the progress of our organization. There were presented valuable and interesting papers and committee reports, all of great importance in the onward march of the electrical industry.

In a consideration of our progress we naturally give great weight to the developments which are reviewed in the committee reports and to the completeness of the technical program of the convention. It is, of course, true that our conventions and our regional meetings record the advances which have been made in the electrical field, but we must not let the knowledge of this fact obscure in our minds the progress that finds its real and solid foundation in the Section meetings; for after all, it is largely in the Sections that the men are developed upon whom much of the progress depends.

I can think of no message of more importance with which to close the year than one that emphasizes again the opportunities of the Sections. The new chairmen and committees will soon be completing their plans for the coming year. The suggestions contained in last January's message may be of help. No more successful plan has been found than one that gives the fullest opportunity for the development of the individual member.

Our incoming president has a deep-seated interest in the Sections, already expressed in many ways and particularly in his three years of splendid service as chairman of our Sections Committee. With his whole-hearted, sympathetic, and active support, supplemented by the organized facilities of our excellent headquarters' staff, the progress of the Institute is assured and the electrical engineers of America will have cause for increasing pride in their profession, and in the society of their profession.

R. F. Schuchardt

President

Some Leaders of the A. I. E. E.

Frederick Bedell, member of the Institute since 1892, Manager 1914-17, and Vice-President 1917-18, was born in Brooklyn, N. Y., April 1868. After an undergraduate Arts course at Yale, he took graduate courses in science, engineering and mathematics at Cornell University, receiving the degree of Doctor of Philosophy and joining the instructing staff in 1892. In 1893 he was appointed Assistant Professor of Physics, and, in 1904, Professor of Applied Electricity, a position he still holds.

Doctor Bedell has performed valuable service to the Institute not only by contributing papers—many of which are outstanding,—and by participating in discussion, but also active service in its principal committees, as member of the Meetings and Papers, Standards, Library and Sections committees, Chairman of the Electrophysics Committee and of the Subcommittee on Wave-form Standard, and as member of the committee of award of the Edison Medal and for many years as director. With his clarity of vision his influence on the electrical engineering profession has been marked.

His most important contributions in electrical engineering have been his experimental investigations and theoretical studies dealing with alternating currents, a field in which he was a pioneer. His first paper before the Institute in 1892, on the *General Solution for the Current Flowing in a Circuit Containing Resistance, Self-Induction and Capacity, with any Impressed Electromotive Force* introduced the use of j as an operator in the solution of alternating-current problems. This and other papers written in collaboration with Doctor A. C. Crehore, developing analytical and graphical methods for solving alternating-current problems now well known, formed the basis of the book "Bedell and Crehore's Alternating Currents" which was the first systematic treatise in its field, and for many years a standard text. It received world-wide circulation in several languages. The principles first enunciated in it have been included in nearly every book dealing with alternating currents that has subsequently appeared.

In addition to about one hundred articles, Doctor Bedell has published the following three books on electrical engineering: 'Alternating Currents," "The Principles of the Transformer" and "Direct and Alternating Current Manual." In these he has had many "firsts" to his credit, including the circle diagram for the transformer in 1893 (extended later by others to include the induction motor), the first paper on "reactance" (jointly with Steinmetz, TRANSACTIONS, 1894) the introduction of "reactive power," the first graphical analysis of the operation of the synchronous motor (with Ryan, *Journal Franklin Institute*, 1895) and the predetermination of transformer regulation. In a three-page paper with Crehore in 1892 (*American Journal of Science*) he called attention to the limitations of the telephone due to the differences in the rates of decay of high and low frequencies, and pointed out that this effect was diminished by the introduction of self-induction, a theoretical deduction substantiated later by the general use of loading coils. The principle of reciprocal vectors was presented in a paper on "Admittance and Impedance Loci" before the Physical Society of London in 1896.

The same high standard has been attained in his contributions to mechanical and aeronautical engineering. His books "Airplane Characteristics," "The Air Propeller," and "The Airplane" rank high in their field; in them the principles of flight have been clearly developed without being encumbered by structural minutiae on the one hand or by abstruse mathematics on the other.

In the field of physics his work has been no less noteworthy. For twenty-nine years he was editor of *The Physical Review*, a period in which physics in this country—as well as electrical engineering—developed from youth to maturity. The principal American contributions to physics during this period passed under his scrutiny. He was contributor to Johnson's Universal Cyclopaedia and to the Standard Dictionary and was editor (for electricity) of Webster's New International Dictionary. He has served as secretary of the Council and as General Secretary of the American Association for the Advancement of Science. He has a number of patents, both United States and Foreign, on improvements in transmission of power and intelligence.

Doctor Bedell's present activities are reflected in two papers before the regional convention of the Institute in 1927 on *Non-Harmonic Alternating Currents* and *The Stabilized Oscilloscope: a Cathode Ray Oscillograph with Linear Time-Axis*. In his theoretical work he is at present interested in extending the use of vectors (in some cases in more than one plane) to apply to alternating quantities without the limitation of the so-called sine assumption. He is experimenting on methods for observing such quantities and is completing the development of an improved oscilloscope, extending its use to the study of light and sound, as well as electrical phenomena.

The Engineering Division of Iowa State College, Ames, Iowa, has inaugurated a personnel service which should prove of mutual benefit to the industries and the engineering graduates. With the cooperation of the engineering student council "Personnel Service Leaflets" have been published for the senior engineers and fifty sets of these leaflets were sent to the leading industries early in January. Each year new sets of leaflets will be sent by the college to these industries as well as to other industries that may be interested.

Each leaflet gives a portrait of the student, his name, college course, and date of graduation. Many other details as to his training, experience and qualifications are included in the leaflet, such as his age, health, college activities, expenses earned, etc.

Abridgment of

Master Reference System for Telephone Transmission

BY W. H. MARTIN*
Member, A. I. E. E.

and

C. H. G. GRAY†
Applicant for Membership

Synopsis.—The telephone transmission system described here is the Master Reference System of the Bell System for the expression of transmission standards and the ratings of the transmission performance of telephone circuits. The transmitter and receiver elements of this system are reference standards for the ratings of the transmitting and receiving performance of terminal station sets.

A replica of this reference system installed in Paris has been adopted as the Master Reference System of the International Advisory Committee on Long Distance Telephone Communication in Europe. The establishment of these two master systems provides a common reference for the telephone transmission work of the Bell System and the telephone administrations which are members of this International Advisory Committee.

* * * * *

THE Master Reference System for Telephone Transmission, as its name indicates, is to serve as the fundamental circuit in the ratings of the transmission performance of telephone circuits. In describing this system, therefore, it will be advantageous to outline first the general considerations underlying the methods of determining and specifying these ratings and their applications.

The conversions and transfers of energy which constitute the process of telephone transmission result in general in a difference between the speech sounds at the sending end of the telephone circuit and the sounds reproduced at the other end in the ear of the listener. These reproduced sounds may differ from the original in three important respects; their loudness, distortion, or degree to which their wave-shape departs from facsimile reproduction and the amount of extraneous sound or noise which accompanies them. From the standpoint of telephony, the major importance of a difference between the original and reproduced sounds is determined by its effect upon "intelligibility," that is, the degree to which the latter sounds can be recognized and understood by the listener when carrying on a telephone conservation. The tolerable departure of the reproduced from the original sounds is limited also by certain effects which are noticeable to the listener before they materially affect intelligibility, such as loss of naturalness.

Measurements of intelligibility are of utmost importance in rating the performance of telephone circuits, but they are unduly cumbersome for direct use in the detailed development and design of telephone circuits and their many parts, particularly where small effects are concerned. It has been desirable, therefore, to handle telephone transmission work in two steps. One natural division is suggested by the statement that intelligibility is a function of the relation between the output and input speech sounds, and of the psychological reaction of the listener to these output sounds. Because of the complex nature of the speech sound waves, however, it has been found more practicable to treat the transmission performance of telephone circuits in the following two parts: (1) the physical performance of the circuit, and (2) the relation between physical performance and intelligibility. The physical performance of a circuit is taken here to cover the transmission characteristics which can be specified in terms of the performance for single frequencies, a number of frequencies being taken to cover the range which is important for the reproduction of speech sounds. These measurements of physical performance cover such things as the response-frequency characteristic of the circuit over the range of speech frequencies, the distortion due to non-linear elements, phase distortion, and the extraneous currents which cause noise. These determinations of physical performance do not include measurements of the speech sounds themselves, nor of the functioning of the talker and listener. This differentiation is advantageous in segregating the studies of speech sounds and of the psychological phases of the work, and permits the design of the operating plant and a large portion of the development work to be carried out on a physical basis.

The determination of the relation between intelligibility and the physical performance of a telephone circuit is a laborious process, because persons play the parts of generators and meters and a number of people must be used in both parts to take into account the normal ranges of their performance. The goal of this portion of the work, has been, therefore, to establish suitable relations which will permit the determination of the intelligibility of a circuit by computations which start with the physical characteristics of the circuit. This work[1] has involved determinations of the capabilities of circuits having various kinds of physical

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1. For all numbered references see end of paper.

29-110

characteristics to reproduce intelligible speech, investigations of the nature of speech sounds and hearing, and of people's customs in using the telephone.

Prior to the time when suitable means were available for measuring the physical performance of telephone circuits, and when the kinds of circuits in commercial use were quite similar in their distortion characteristics, the practise was adopted of rating the performance of a circuit by comparing it, on a loudness basis, with a reference circuit which was adjustable in attenuation and whose distortion was closely similar to that of the commercial circuits. In such a comparison, a determination is made of the equivalence of loudness or volume of these two circuits by talking alternately over them and adjusting the reference circuit until the sounds coming out of the two receivers are judged to be equal. For the conditions where volume is the important controllable characteristic of telephone circuits, these loudness comparisons constitute a practicable and effective means of indicating the performance of these circuits.

The reference circuit adopted about twenty-five years ago for these loudness comparisons consisted of transmitters, receivers, station sets, cord circuits and a line, of types which were then used commercially. In this reference circuit the line was an adjustable artificial line simulating a No. 19 A.w.g. cable circuit having a capacity per loop mile of 0.054 μf. The amount of cable in this line to give a loudness balance was taken as the rating of the circuit under comparison. This reference system has been called the Standard Cable Reference System.

In addition to this rating of the performance of a telephone circuit, the standard cable reference system has had other applications. Certain settings of this reference system were selected as specifying the standards of transmission which were to be provided in the design and operation of commercial circuits for the several kinds of service, such as local and toll. The effect of introducing or changing any part in a commerical circuit was rated in terms of the amount of cable by which it was necessary to change the line of the reference system to produce the same effect on the loudness of the reproduced speech sounds. Likewise, the transmitters and receivers of this reference system were used as reference instruments for the comparison and rating of other transmitters and receivers.

This cable reference system has played a very important and necessary part in the development of telephone transmission, in that it has provided a ready means of rating the performance of the various parts of the system and of any changes, and has made it possible to design commercial circuits to provide a predetermined grade of service. The performance of this system was specified by stating the kinds of apparatus and circuits used. The performance of the elements of the electrical portion of the system could be checked by voltage, current, and impedance measurements, but for the transmitters and receivers, reliance for constancy of performance was placed primarily upon the careful maintenance and frequent cross-comparisons of a group of transmitters and receivers which were specially constructed to reduce some of the sources of variation in the regular product instruments. In this way, reasonable assurance of the performance of the reference system was secured. This system has been widely used both in this country and in other parts of the world, and the performances of the various systems have been kept in accord by frequent circulation of calibrated transmitters and receivers.

As the telephone art has developed, modifications have been found to be desirable in this reference system to make it more suitable for its purpose. Telephone instruments and circuits have been designed and used which have less distortion than existed in the corresponding parts of the cable reference system. For this reason it is desirable to have as a new reference system one with which the transmission over the most perfect telephone circuit or over some less perfect one may be simulated at will. The change of the unit of transmission from the mile of standard cable to the decibel[2] has brought about the need for a change in the line of the reference system.

A reference system such as that described here, in which the essential elements are so constructed as to reproduce speech with a high degree of perfection and with which provision may be made for modifying the speech in definite and reproducible ways, affords a convenient means for studying the capabilities of telephone circuits of different physical performances. These investigations, however, are outside the purpose of this paper, which is to describe the new reference system and its application in making volume ratings.

General Requirements

The outstanding conception of the new reference system is that its performance should be suitable to serve as a reference base line for indicating the performance of all telephone circuits and that the transmitter and receiver elements of the new system should provide similar base lines for the performance of electro-acoustic converters. To meet these needs properly, the performance of the system and its parts should be capable of being measured and definitely specified in terms of physical quantities.

The most important requirement, then, for the reference system is that the physical performance of the system and of its component parts should be capable of being measured and definitely specified in terms of physical quantities.

The second main requirement is that specifiable and predeterminable changes can be made with respect to the performance which is selected as the reference. These changes must be capable of varying the relation between the loudness of the reproduced sounds with respect to the initial sounds, the distortion of the wave-

shape of these reproduced sounds, and also the amount of noise accompanying these reproduced sounds.

For convenience in specifying these requirements, it has been found desirable to impose another requirement; namely, that the system be capable of giving a performance which is as free as possible from distortion and noise. This requirement is also of advantage in insuring that the reference system and its parts will have less distortion than any circuit or instrument with which it may be compared.

For convenience in use, it is highly desirable that the performance of the reference system and its parts be constant for a reasonable time under normal operating conditions.

Description of Master Reference System

The master reference system[3] employs a transmitter and receiver which are capable of a high degree of freedom from distortion. The transmitter is of the condenser type[4] and the receiver is of the moving coil type.[5] Both these instruments are materially lower in efficiency than commercial types of apparatus, but this condition is compensated for by the use of multi-stage vacuum tube amplifiers. These instruments, together with their associated amplifiers, constitute reference standards for converters between acoustic and electrical energy. The third necessary element of a telephone transmission system,—namely, the line,—is provided by a network of resistance elements. Such a line can be made to provide uniform attenuation over a wide frequency range, and can be made to control the magnitude of this attenuation over a large range. This line is taken as giving a reference performance for lines.

The specification of the performance of such a system is based on the principle of the thermophone, which is a converter of electrical energy into acoustic waves by means of the heat generated by the passage of an electrical current through a resistance. From a knowledge of the form and physical constants of this resistance element, of the medium in which it is used, and of the electrical input to the element, the acoustic pressure generated in a chamber of known size can be determined by theoretical considerations.[6] The performance of the condenser transmitter is determined by making its diaphragm a wall of a simple closed chamber in which the thermophone is placed. By this means a known pressure wave of any frequency over the range desired can be impressed upon the diaphragm of the transmitter. The voltage output of the transmitter for a specified circuit condition is then measured. From this measurement the ratio of the voltage output to the acoustic pressure on the diaphragm is established for that instrument and circuit condition. With the performance of the transmitter thus established, the performance of the receiver element of the reference system is measured by acoustically coupling the receiver to the condenser transmitter, so that the receiver actuates the transmitter, and then determining the relation of the pressure generated by the receiver in the coupler to the voltage input to the receiver. The performance of the line element is determined by well-known means. The performance of the whole system can then be expressed in terms of the pressure produced by the receiver with respect to the pressure on the diaphragm of the transmitter.

The performance of this system is practically free from distortion for the energies which it is required to handle, and probably materially excells in this respect that of any previous system. With this system, volume relations between output and input sounds can be varied over a wide range with practically no accompanying distortion. In comparing such a system, however, with commercial systems it is advantageous also to be able to control distortion. This is particularly the case when using the instruments of the master system for rating the volume efficiency of commercial types of transmitters and receivers. To facilitate this, arrangements are made for the introduction into the amplifiers associated with the transmitter and receiver, of networks which may be designed to give a variation of efficiency with frequency which corresponds to that obtained with commercial apparatus. These networks and their distortion effect can of course be definitely specified. The line element of this master system can be replaced by a line or network giving any type of distortion desired. Also, known amounts of extraneous currents to produce noise can be introduced into this circuit without otherwise appreciably affecting its performance.

Fig. 1—Master Reference System for Telephone Transmission with Associated Calibration Apparatus

The master reference system with associated calibration apparatus is shown in Fig. 2. This equipment, mounted on steel panels and racks, and arranged as shown, is installed in a room, shielded from acoustical and electrical disturbances, at the Bell Telephone Laboratories in New York City. In Fig. 2 the transmitter, line, and receiver of the reference system are

shown on the three racks at the right. The calibration apparatus, consisting of an oscillator, thermophone, vacuum tube voltmeter, and volume indicator are shown on the other three racks. A schematic diagram of the master reference system is shown in Fig. 3.

Fig. 10 shows, for particular amplifier adjustments the frequency response characteristics of the reference transmitter, reference receiver and the complete reference system with 0 db. in the line. The characteristic

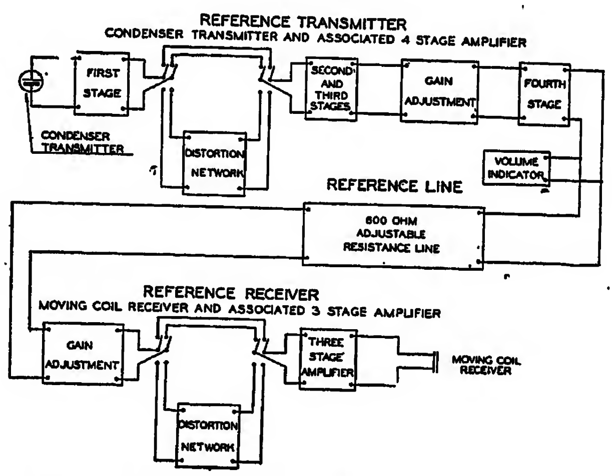

Fig. 2—Schematic Diagram of Master Reference System

of the reference transmitter and also of the reference receiver in each instance is that of the instrument and associated amplifier combined. However, as the frequency response of each of the amplifiers is uniform within 2 db. from about 50 to 10,000 cycles per second, the curves shown are essentially the calibrations of the instruments determined as described above.

Application of the System

The results of articulation tests over the master reference system when adjusted for optimum volume are practically equivalent to those obtained in direct air transmission in a quiet room. This system and replicas of it are particularly adapted for use in making articulation studies, since they provide an approximately ideal system with which the loudness of the output sounds can be varied distortionlessly over a wide range and in which distortion networks of various types and controlled amounts of noise can be introduced. In this way the effects on articulation of various kinds of physical performance of a telephone circuit can be investigated.

The master reference system itself will be used chiefly for the important work of rating working standard systems and instruments.

European Master Reference System

In Europe, the recommendation of technical standards for telephony is a function of the Comité Consultatif International des Communications Telephoniques a Grande Distance (C. C. I.), which is composed of representatives of the various European telephone administrations. In 1926, at the invitation of the C. C. I., representatives of the Bell System met in London with a committee appointed by the C. C. I. to consider the adoption of a transmission reference system. This committee recommended that the C. C. I. adopt as their master reference system one essentially the same as the one described in this paper, and that such a system, which would be a replica of one in New York, be installed in Paris in the laboratory of the C. C. I. and be known as the European Master Reference System. This recommendation was adopted by the C. C. I.

Subsequently, some improvements were made in the system, and two duplicate systems, each with its associated calibrating apparatus, have been constructed. One of these is now in the Bell Telephone Laboratories in New York and the other in the laboratory of the C. C. I. in Paris. The C. C. I. further recommended that primary and working standard systems, used in the telephone administrations adhering to the C. C. I., be calibrated in terms of the Master Reference System.

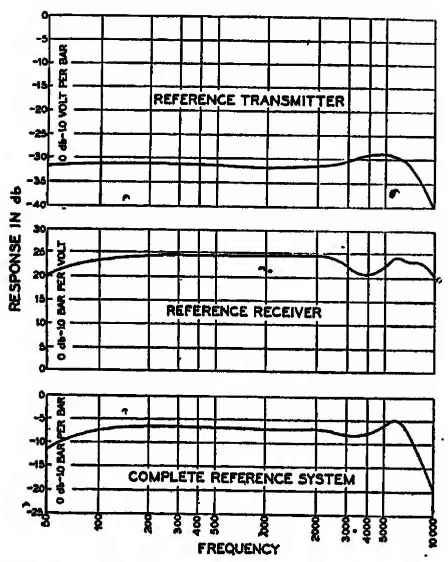

Fig. 3—Response Characteristics of Reference Transmitter, Reference Receiver and Complete Reference System with 0 db. in the Line

The establishment of these two master systems insures the use of a common base line for the expression of transmission standards, and for the ratings of the transmission performance of telephone circuits in the two continents where the telephone system has had its greatest development.

List of References

1. "Speech and Hearing" by H. Fletcher, published by D. Van Nostrand Co.

2. "Decibel" (db) is the name for the Transmission Unit which has superseded the "mile of standard cable," W. H. Martin, *Bell System Technical Journal*, January, 1929, and A. I. E. E. Journal, March, 1929.

3. A discussion of a preliminary model of this system was

given in "A Telephone Transmission Reference System" by L. J. Sivian, *Electrical Communication*, October, 1924.

4. The theory and operation of this transmitter are discussed in papers by I. B. Crandall, *Physical Review*, June, 1918, and E. C. Wente, *Physical Review*, July, 1917, and *Physical Review*, May, 1922.

5. This instrument, which is similar in many respects to one described by E. C. Wente and A. L. Thures in the *Bell System Technical Journal*, January, 1928, will be discussed in a future paper by the same authors.

6. The theory of the thermophone as a precision sound of sound is outlined in papers by H. D. Arnold and J. H. Crandall, *Physical Review*, July, 1917, and by E. C. Wente in the *Physical Review*, April, 1922.

Abridgment of

Shielding in High-Frequency Measurements

BY JOHN G. FERGUSON[1]

Associate, A. I. E. E.

Synopsis.—*The purpose and usefulness of shielding in high-frequency measurement are outlined. General principles of electrostatic shielding are developed as applied to simple impedances and to networks of impedances, particularly to bridge networks. Practical applications of these principles to the shielding of adjustable impedances, and in the construction of actual bridge circuits are described.*

* * * * *

Introduction

SHIELDING of high-frequency measurement apparatus has for its immediate object the control of certain electromagnetic and electrostatic couplings, unintentionally introduced in the usual high-frequency circuit. These couplings are represented by stray admittances between the various parts of the system, either direct or to ground, and mutual impedances resulting from stray magnetic fields. In general, the control of these couplings is exercised for the purpose of attaining an accuracy of test that cannot be obtained so readily in other ways.

It may be argued that by extensive separation of the physical parts of circuits and apparatus, any couplings may be decreased in value, and in consequence errors caused by them can be reduced, thus eliminating any need for shielding. But there are obvious limits to the extent to which this method can be employed practically. In the case of electrostatic coupling to ground, it is scarcely of any value, and in any case, excessive separation of the parts of a circuit introduces other errors due to the length of the wiring involved. Accordingly, it is usually necessary where the maximum accuracy is desired, to have recourse to shielding.

Principles of Electromagnetic Shielding

The necessity for electromagnetic shielding is limited practically to wound apparatus such as coils and transformers. It may be reduced to a minimum by using high permeability core material wherever possible in coils and transformers, and by using some form of closed core such as the toroidal type. By these means stray fields may be reduced to a relatively low figure. However, there are cases where the remaining coupling may be objectionable and it is then necessary to use shielding to reduce still further the amount of these stray fields.

Two types of shielding may be used. A high permeability material may be used for the purpose of short-circuiting the stray field. The principles of this method of shielding are described fully in another paper and will not be considered further here.

In the case of air-core coils, which are often of the solenoidal type since the advantage of using the toroidal form is less in this case, and for coils used at very high frequency where heavy magnetic material is not so effective, shields of non-magnetic material may be used to confine the field by the effect of eddy currents. For these shields, a material of high conductivity is used, usually copper, and the principal consideration is the spacing of the shield from the coil rather than the thickness of the shield itself.

There is always a loss in efficiency due to the losses in the shield, and this loss is greater the closer the shield is placed to the coil; that is, the stronger the field in which the shield is placed. However, even with solenoidal air-core coils, very effective shielding may be attained by moderately thick copper shields, spaced about the distance of a diameter from the coil.

Principles of Electrostatic Shielding

In both theory and practise, all measurements assume that between different terminals or junction points of the system there are impedances having values known to a degree of definiteness consistent with the accuracies sought in the test. In an unshielded circuit, it will generally be the case that the elements connected by the various terminals or junction points will not provide impedances so definitely known; or, in other words, will not carry all of the current flowing between the points in question.

Resistors. In the case of the simple resistor such as

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pictured schematically in Fig. 1A, there are admittances from different parts of the conductor to other parts of the whole system and in particular to ground. These, of course, act to modify the effective impedance between the terminals and as they vary with the location of the resistor, the result is that its effective impedance is variable and known only for the location in which it has been calibrated. One of the first objects to be accomplished by shielding is to remedy this type of indefiniteness of value. This is done by mounting the elements within a shield of conducting material and in fixed space relation thereto, as shown in Fig. 1B. Thus, the circuit element has direct admittances only to the shield and as these are of fixed value the terminal to terminal impedance becomes independent of the location of the shielded element.

If, then, we connect the shield to any fixed point in the circuit element such as one terminal, all of the current transferred by the shield admittances passes to or from the circuit at this particular point. This concentration of admittance enables the ready evaluation of the effect produced by it when the element is used in conjunction with others in a complete measuring system. We may summarize all of this to form a fundamental rule of shielding; *viz.*, "the association of an element of a system with a shield so that all admittances

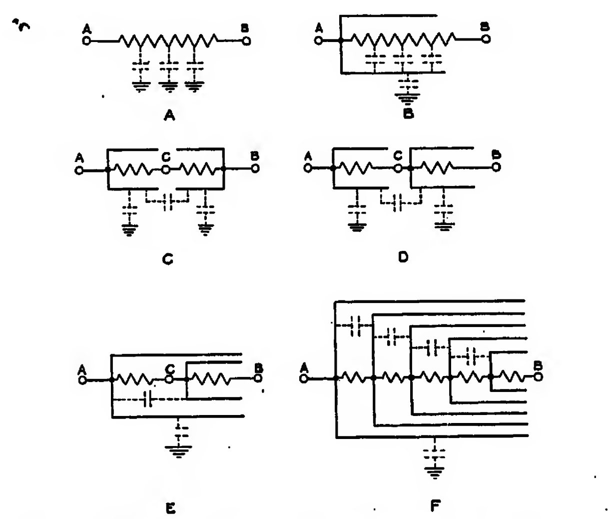

Fig. 1—Methods of Shielding Series Impedances

from the element to other parts of the system or to ground are confined to one terminal."

Series Impedances. In the case of two impedances in series as shown in Fig. 1C, shielding may be accomplished by connecting one shield to terminal A and the other shield to B. In addition to the effects described for a single impedance there will then be admittance between the two shields which will depend on the position of the apparatus. This admittance is slightly more objectionable than admittance from shield to ground, since while we may ground either A or B, there will always be an admittance from one shield to ground which will be variable.

The shields may also be connected as shown in Fig. 1D, in which case the admittance between shields appears across the first impedance. If now we extend the shield connected to A to include the other shield as shown in Fig. 1E, we have introduced a fixed admittance across $A\ C$ and have variable admittances to ground from A.

If this combination of impedances can be grounded at A, we have a complete system having no variable admittances. The principle may be extended to include any number of series elements, the effect being to place admittances across all of the elements but one, and

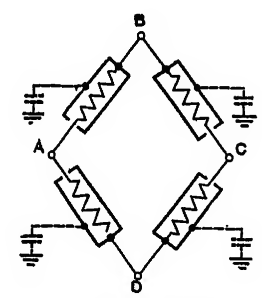

Fig. 3—Bridge Network Using Shielded Impedances

to enclose the whole system in one outer shield. Such a system for five elements in series is shown in Fig. 1F.

Parallel Impedances. The shielding of parallel impedances is comparatively simple, since any number may be shielded individually and the shielding all connected to the same point. If they are not shielded from one another there will be distributed admittances between them which may cause errors. Preferably each should be shielded individually.

By following the procedure outlined above, it is comparatively simple to apply shielding to any combination of impedances in series or in parallel in such a way that we will have all admittances to external conductors from the shielded elements concentrated at terminals or junction points of the system.

Circuit Shielding. In many cases it is impossible to connect the above combinations in a given circuit so that the outer shield is grounded. In such cases it is necessary to determine from the position of the network in the system the effect of admittances from the shield to other shields and to ground. To illustrate, let us take the simple bridge circuit shown in Fig. 3. The four impedances constituting the arms each may be considered as any combination of individual impedances. With the shields connected as shown, the total admittances are reduced to three; between B and D and from B and D to ground. These admittances do not affect the bridge balance and, therefore, are not objectionable. However, if we add input and output circuits and follow the same system of shielding, we get the result shown in Fig. 4. In this case it is impossible to concentrate all of the admittances at B and D. Neglecting for the present the ground at D, we have added variable admittances from A to B, to D and to

ground. The only way of overcoming this difficulty is to use double shielding as shown, adding an outer shield to the impedance across $A\ C$ and connecting it to D. This puts a fixed admittance across $A\ D$, but as we have not made any distinction between the four arms of the bridge, this admittance may generally be placed across an arm where it can be taken care of satisfactorily. If in addition we ground D, the admittances reduce to a single one from B to ground.

Admittance to Ground of Unknown Impedance. From

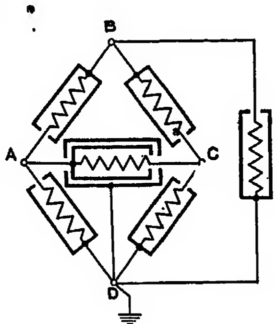

Fig. 4—Completely Shielded Bridge Network

the above it would appear that the general bridge circuit is susceptible of a simple complete solution, since the shielding shown in Fig. 4 is equally applicable to all cases. This would be true if the unknown impedance to be measured in the circuit had no admittance to ground. This is usually not the case. We generally have an additional requirement, that the potential condition with respect to ground of the impedance during the measurement be defined in some way.

If the impedance can be connected across one arm of the bridge and its value is desired with one terminal grounded, the circuit shown is satisfactory. However, these are special conditions, and where the impedance to be measured forms only part of the total series impedance of an arm, or where the potential requirements are different, such as the requirement that the coil be measured with its terminals at equal potential to ground, the bridge shielding becomes a more serious problem.

In general, the question of selecting the most suitable system of electrostatic shielding for a specific test circuit, resolves itself into a determination of the most advantageous location of the admittances which, as described above, have been arranged to terminate at certain terminals or junction points. The facts which need to be taken into consideration are usually so varied that no general rules can be established. A few typical examples in which shielding is applied with considerable success will, therefore, be taken and the selection of suitable shielding for these circuits discussed.

Examples of Electrostatic Shielding

Adjustable Resistor. An adjustable resistor usually takes the form of a dial box in which there are from one to six dials arranged in series in decade formation. Each decade considered by itself is no more difficult to shield than a single resistor. The admittance of the shield, however, has a different effect at each step which means that the phase angle varies with the setting of the dial. If the admittance to the shield is small, this effect will not be very great and in any case it is always the same for a given setting and hence may be included in a calibration.

In shielding several decades in series, admittances between decades are introduced. Effects due to these admittances can be taken care of completely by the use of nested shields as already shown in Fig. 1F. For a resistance box of five or six dials, this type of shielding becomes prohibitive from a size and cost standpoint and in consequence such shielding is usually not attempted. The use of a single shield for all decades of a resistor means that the impedance of two or more dial settings is not exactly equal to the sum of the impedances of each setting by itself. If the difference is appreciable the only alternative to the expensive type of shielding mentioned above is the use of a calibrated value for every combination of dial settings. This error in additions is smaller the lower the resistance, and usually may be neglected for values below 100 ohms.

In the actual construction of such a resistor it is essential that the shielding be complete, particularly at the dials. Since the effect of the hands in operating the dials is more valuable than any other coupling, it is of very little value to place an unshielded dial box in a metal shield which allows admittance from the hand of the operator to the circuit.

Adjustable Inductor. The same considerations apply

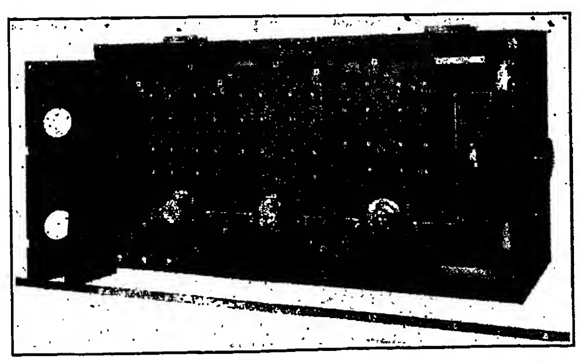

Fig. 6—Three-Dial Shielded Adjustable Inductor

to an inductor as to a resistor except that on account of the larger physical size of the former, larger admittances are associated with it and for that reason it is usually necessary to use nested shields. Fig. 6 shows a standard inductor consisting of three decades and an inductometer using four shields. The three top panels have been removed showing the method of nesting the shields, and the construction used to bring the dial controls through the shields.

The admittance between shields is considerable, but due to the method of construction, the largest admit-

tance is across the smallest inductance and there is no intershield admittance added across the highest decade. Accordingly, the effect is not so serious as might be thought at first glance.

Adjustable Capacitor. The units of an adjustable capacitor are practically always connected in parallel and the problem of shielding them is that of shielding a single capacitor. It is desirable to shield the decades from each other if the capacitances are small as this facilitates calibration and is easily effected. Where the capacitance is large,—say over 10,000 $\mu\mu$f.—this precaution is unnecessary.

Bridge Circuits. The general principles of bridge shielding have been discussed by Campbell[3] and the equal ratio-arm comparison bridge has been discussed in detail by Shackelton.[4] The mechanical construction of the bridge itself exclusive of standards is simplified by the fact that there are comparatively few dials to be brought through the shielding.

This bridge with the standards described above may

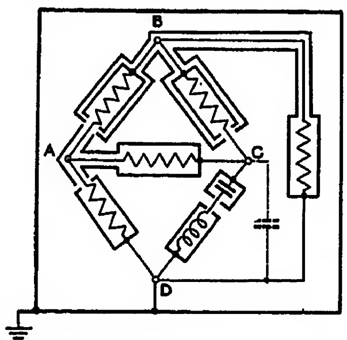

Fig. 7—Shielded Resonance Bridge Network

be used for a wide variety of measurements. A rather simple modification is the so-called resonance bridge, in which the bridge unit is an equal ratio-arm comparison type, and a resistance is balanced in one impedance arm against a capacitance and an inductance connected in series in the other impedance arm. The balance is usually effected by adjusting the resistance and capacitance.

The shielded circuit of such a bridge is shown in Fig. 7. The capacitance from C to D introduced by the shielding may be compensated for in the usual way by the addition of an equal capacitance across AD. In this circuit, the coil is usually measured under the condition of one terminal at ground potential. Thus, D is shown strapped to the ground shield. For this case, the shielding may be simplified considerably. Fig. 8 shows the mechanical construction of the combined resistance and capacitance standard used with the bridge unit for these measurements. The unit is shown with the top of the outer shield removed. The capacitance, in accordance with the shielding diagram, is double shielded, while the resistance requires only a ground shield.

Another bridge circuit which is interesting from the shielding point of view is the Owen bridge.[5] A detailed discussion of the shielding involved in this type of bridge is contained in a previous paper by the present author.[6]

Details of Construction. So far, we have discussed the admittance introduced by the shielding without going into details as to the form which this admittance takes, although it has been broadly assumed that it is principally due to capacitance. Since it generally forms an integral part of the measuring circuit, it is obvious that

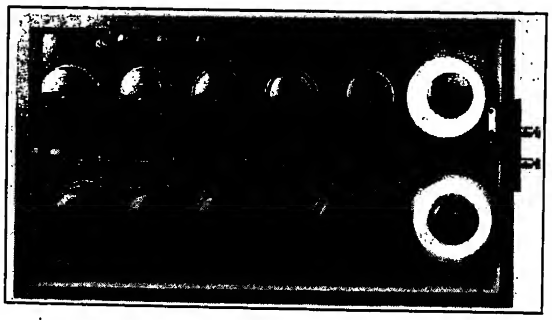

Fig. 8—Shielded Resonance Unit, Top Panel Removed

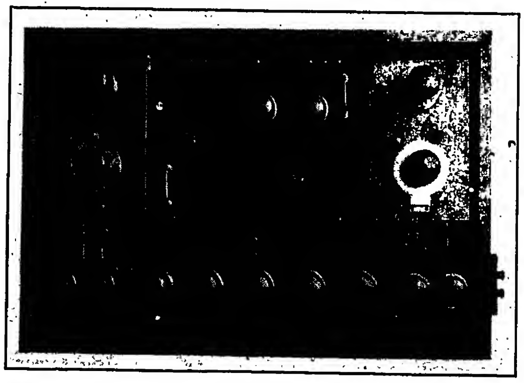

Fig. 9—Shielded Comparison Type Bridge, Top Panel Removed

as much consideration should be given to it as to the rest of the circuit. While the admittance is due essentially to capacitance, the necessary supports introduce a certain amount of conductance which causes some difficulty in obtaining compensation.

For instance, in the typical equal ratio-arm bridge circuit where the admittance across one arm requires compensation in the other arm, it is a simple matter to use an adjustable condenser for the compensation of capacitance. However, if the conductance is left uncompensated it may cause considerable error, particularly in the measurement of high impedances at

3. G. A. Campbell, "The Shielded Balance," *Electrical World and Engineer*, April 2, 1904, p. 647.

4. W. J. Shackelton, *A Shielded A-C. Inductance Bridge*, A. I. E. E. Journal, Feb. 1927.

5. D. Owen, "A Bridge for the Measurement of Self Inductance," *Proc. Phys. Soc. London*, October, 1914.

6. J. G. Ferguson, "Measurement of Inductance by the Shielded Owen Bridge," *Bell Sys. Tech. Jl.*, July, 1927, pp. 375-386.

high frequencies. For this reason, it is desirable that all shields be supported by insulating material of the highest quality such as hard rubber, glass or quartz and that only the minimum amount necessary for satisfactory mechanical support be used.

It will be noticed in Fig. 4 that the wiring is shielded by brass tubing. This shielding is insulated from the conductor by means of bushings, only enough being used to insure that the conductor and shield do not change their relative positions with respect to each other. The insulating bushings used most generally are either hard rubber or glass beads.

Even after taking these precautions, it has been found necessary for the highest precision work at the highest frequencies, to introduce a conductance compensator in the form of a small adjustable condenser in which the dielectric is an insulating material such as phenol fiber. By this means the amount of conductance in one arm may be varied to obtain correct compensation. The balance once obtained, does not vary appreciably with frequency.

Conclusion

It has been impossible to go into very great detail in this brief paper on the subject of shielding. The attempt has been made, therefore, to outline a few general rules and to give representative examples of typical measuring circuits. It will be noted that the examples have been limited largely to the bridge circuit. This is because our experience has shown that this circuit is the most flexible and accurate over the whole of the frequency range over which precise impedance measurements have been made, and because the problems of shielding it are sufficiently difficult and varied to give satisfactory examples of the solution of rather complicated problems. The principles of shielding given have been found to apply equally well at all frequencies and it has been found that up to the maximum frequency at which precision measurements have been made, the shielding methods developed for use with moderate frequencies require practically no modification as the frequency is increased. Experience with measurements and measuring circuits up to 2000 kilocycles, makes it appear probable that when precision measurements are made at still higher frequencies, the shielded bridge circuit will continue to remain the most satisfactory measuring circuit.

Abridgment of

High-Frequency Portable Tools and Equipment

BY C. B. COATES[1]

Member, A. I. E. E.

Synopsis.—This paper presents practical information regarding the application of high-frequency (180-cycle) induction motors with low-resistance rotors to portable electric tools.

In order to compete with existing tools it became necessary to increase the rotor speed above 60 cycles, and 180 cycles per second was adopted as commercially practical. Several advantages are shown. Due to a smaller drop in speed with this type of motor than with the direct current and the universal motor, greater power is developed. Because of better speed regulation the life of the cutting tools is longer. Less weight and lower maintenance costs result from this application.

Several new tools for special work are described. The desirable regulation of the frequency converter or motor-generator is given as not exceeding 8 per cent.

Older Types of Tools

The application of the term "high-frequency" to portable tools and equipment is no doubt a misnomer in view of the extremely high radio and other frequencies generally understood to come within the scope of this term. As a matter of fact, the frequency now generally employed in so-called high-frequency portable tools is only three times the usual commercial frequency of 60 cycles per second. However, as the name has come to be quite generally accepted as applied to this class of tools, it will be used here.

Electric drills of the portable type were introduced over 25 years ago and to conform to the prevailing conditions in the industrial plants at that time were wound for operation on direct current. These tools were generally series-wound, but several years later the larger sizes were compound-wound to give better speed regulation, which means higher armature speed at full load with limited free speed and consequently greater brake horsepower.

A few years after the introduction of the d-c. drill, a-c. drills were developed. These were built to operate on 60 cycles and other prevailing frequencies such as 40 and 25 cycles. They of course had good speed regulation, but the weight, due to lower rotor speeds being limited to 3600 rev. per min. at 60 cycles and correspondingly less for the lower frequencies, was somewhat of a drawback.

About 1908 the now well-known universal drill was

1. Electrical Engineer, Chicago Pneumatic Tool Co., Cleveland, Ohio.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass. Complete copies upon request.

introduced and has met with great favor on account of its ability to operate interchangeably at practically the same speeds on either direct or single-phase alternating current of a given voltage. The universal tool is series-wound with the typical series motor speed regulation, however.

While the falling off in speed under load was considered to be of advantage in some classes of work, it has now been demonstrated that due to the accomplishment of a greater amount of work, sustained speed of the induction motor is generally preferable. This is particularly true of portable grinders as will be shown later.

It is quite obvious that due to the absence of commutator and brushes, as well as the insulated armature winding, the polyphase induction-motor tool has distinct advantages over the d-c. and universal tools, both as regards speed regulation and lower maintenance costs. One factor which has retarded its adoption, however, has been its greater weight due to the low rotor speed on commercial circuits of 60 cycles or less. All electric tools d-c., universal, and polyphase a-c., have always had the handicap of weight as compared with pneumatic tools, except at the sacrifice of sturdiness. Nevertheless, on account of the more convenient source of power supply many users have put up with the greater weight of the electric tool.

In order to reduce the weight of the induction-motor tool it is evident that we must bring the rotor speed up, and we can do this only by increasing the frequency, since the 60-cycle drills were practically all provided with the minimum number of poles. The synchronous speed of a two-pole 60-cycle motor is 3600 rev. per min., whereas the d-c. and universal tool motors have free armature speeds of from 8000 to 16,000 rev. per min. and even higher in some of the smaller sizes. Under load these armatures slow down nearly 50 per cent which still leaves a speed higher than that of the 60-cycle motor.

High-Frequency Tools

A frequency of 180 cycles per second was adopted for the high-frequency portable tools, which gives a synchronous speed of 10,800 rev. per min. in the two-pole motor used. This is considerably less than the average free speed of the d-c. or universal tool, which is very high. This means longer life for the bearings which are generally of the ball type. The slip under normal full load is from 8 to 10 per cent, giving an average loaded speed of about 9800 rev. per min., which is much higher than the load speed of the d-c. or universal tool with its large speed drop. This, of course, means more power with a given size of rotor.

Several factors governed the selection of a standard frequency for these tools. Since it was necessary to obtain spindle speeds which would conform to the modern cutting tools for the drills, reamers, and abrasive wheels, there must be a point where the reduction in weight of the motor due to higher frequencies would be more than offset by the greater weight of the gearing required to obtain the necessary spindle speeds. From this point of view, the desirable frequency was found to be in the neighborhood of 180 cycles per second. Troubles in ball-bearings and difficulty of lubrication at high speed is another limiting factor, although improvement in both directions indicates the possibility of still higher frequencies.

Thus the high-frequency tools meet the requirements of intensified production in modern industry where portable tools are crowded to the utmost and in many cases get very little care. The outstanding advantages due to this application are:

I. Greater increased power for the same weight, due to the higher loaded speeds of the rotor.

II. Reduced weight for a given power output.

III. Practically constant speed at all loads (8 to 10 per cent slip) which results in the accomplishment of more work.

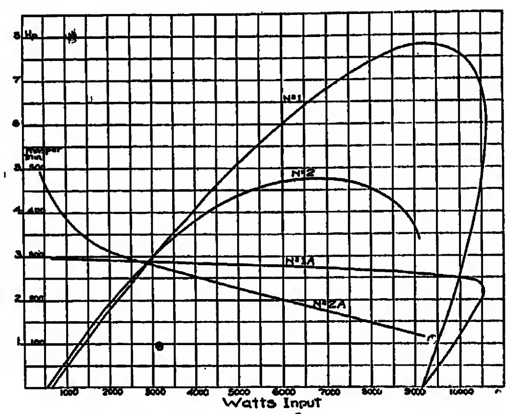

Fig. 2—Comparison of High-Frequency and D-c. Reamers

Curve 1 is brake horsepower of high-frequency reamer
Curve 2 is brake horsepower of d-c. reamer
Curve 1A is speed of high-frequency reamer
Curve 2A is speed of d-c. reamer

IV. Maintenance cost greatly reduced.

In order to give comparisons with other types, a concrete example of the increased power and better speed regulation of the high-frequency tool is shown in Fig. 2. Here the actual watt input is plotted as the abscissas against brake horsepower in curves No. 1 and 2 and against the spindle rev. per min. in curves 1-*A* and 2-*A*. Curves 1 and 1-*A* show characteristics of a high-frequency reamer weighing 50 lb. while 2 and 2-*A* are the corresponding curves of a d-c. reamer which weighs 68 lb. or 36 per cent more. The normal load rating of the high-frequency reamer is 5300 watts input, at which point it develops 5.35 hp. at 280 spindle rev. per min., or with a slip of 6½ per cent. The normal load rating of the d-c. reamer is 3600 watts at which point it develops 3.5 hp. and 265 rev. per min., representing a slip of 56½ per cent. It will be noted that the reserve power above normal full load of the high-frequency tool is large as compared with the d-c. tool. The armature (exclusive

of shaft and the ventilating fan) of the d-c. tool weighs 2⅛ times as much as the high-frequency rotor.

Fig. 3 is the detail curve of the high-frequency reamer shown in the previous curve. Note the well sustained speed at maximum hp. and torque the slip being 15 per cent; also the high power factor.

A cast rotor of relatively low resistance is used in these tools, which gives close speed regulation. When they

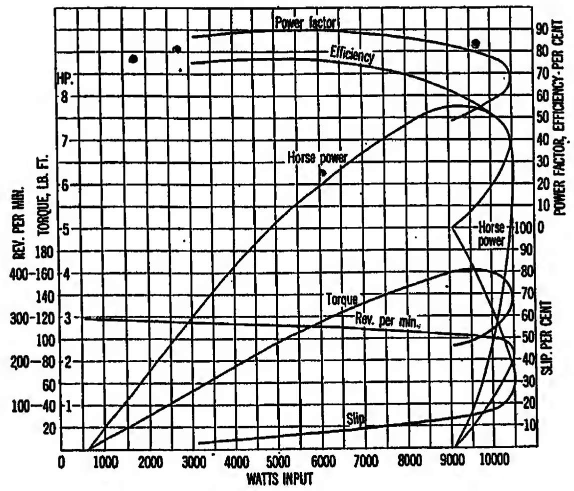

Fig. 3—Characteristics of Large High-Frequency Reamer

were first put on the market it was thought that the smaller tools would be required with considerable speed variation, and a rotor wound with bare copper wire was used making it possible to wind rotors of high or lower resistance as desired. This practise has been discontinued in favor of the low-resistance cast rotor, but a comparison of the characteristics of a small 5/16-in. drill with high-resistance rotor will be interesting.

This drill had a slip of 75 per cent with the torque at the spindle very close to the maximum. The maximum brake horsepower was reached at about 30 per cent slip. With a low resistance rotor in the same stator a slip of 31 per cent was obtained at the same watt input which gave 75 per cent slip with a high-resistance rotor, and the maximum horsepower was developed at 8 per cent slip as against 30 per cent. The maximum brake horsepower was also 12 per cent greater with the low-resistance rotor, these differences being due to difference in rotor resistance.

Perhaps one of the most outstanding examples of the advantages of high-frequency tools is to be found in the portable grinder and buffer. Here the great advantage of sustained speed is very pronounced. The cutting wheel can be operated at the proper and most efficient speed without having to allow a high and dangerous free speed, as is the case with other types of electric and some air grinders. In addition to obtaining the most efficient cutting speeds for the wheels, the wheels themselves give practically double the life at the sustained speeds.

Fig. 5 shows the curves of several types of electric grinders, each having the same weight. The spindle or arbor rev. per min. are shown as the abscissas plotted against the hp.

Curve 1 is of a geared grinder with universal motor and the armature running about three times as fast as the spindle. Note the extremely high no-load speed of 5200 rev. per min., and the speed of 2000 rev. per min. at maximum hp.

Curve 2 is of a geared compound-wound d-c. grinder. The effect of the shunt winding is made apparent in the reduced no-load speed. We also have a greater wheel speed at maximum hp.

Curve 3 is of a two-pole 60-cycle induction-motor grinder without gearing. The synchronous speed is 3600 rev. per min. Here we have good speed regulation and, of course, the absence of gearing is an advantage in that it permits of a larger motor for the same total weight of the tool.

Curve 4 is of a high-frequency grinder geared slightly less than three to one so that the free speed is about 3800 rev. per min. This has good speed regulation and very much more power due to the high rotor speed at full load. This is the only grinder of the group that will successfully carry a six-inch abrasive wheel at proper speed and with sufficient power behind it. The rubber-bonded wheels which permit of a peripheral speed of 10,000 ft. per min. can of course be taken care of by reducing the gear ratio and increasing the arbor speed of

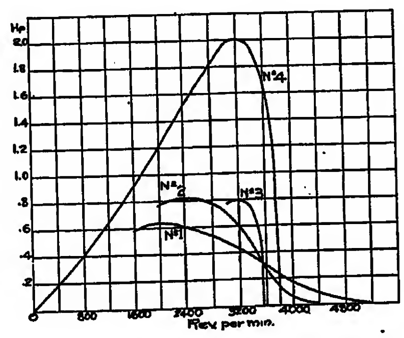

Fig. 5—Comparison of Electric Grinders of Four Different Types

All these grinders have the same weight
Curve 1—Geared universal-motor grinder
Curve 2—Geared compound-wound d-c. grinder
Curve 3—Gearless 60-cycle induction-motor grinder
Curve 4—Geared high-frequency grinder

the high-frequency tool or by using a larger diameter of wheel with the ratio shown.

Just as sustained correct speed makes for longer wear of grinding wheels and abrasive disks, so does it also give long life to reamers and drills. In reaming through a considerable thickness of steel when much metal is to be removed, a tool having great speed variation is apt to produce a clogging of the reamer at extremely slow speeds and burning when the load is lessened with the reamer still in the hole.

A very striking example of the effect of nearly constant speed in increasing the life of the reamer was observed in a bridge fabricating plant with a 50-lb. high-frequency tool, having a synchronous speed of 300 rev. per min. The holes were punched 11/16 in. and reamed to 15/16 in. through assembled plates varying in group thickness from 1¼ in. to 3¾ in. Over 3000 linear inches of this reaming was done with one reamer without regrinding. This was at a reaming rate of 3.7 in. per min., including the time of changing from hole to hole.

As an example of reaming 15/16-in. full-punched holes

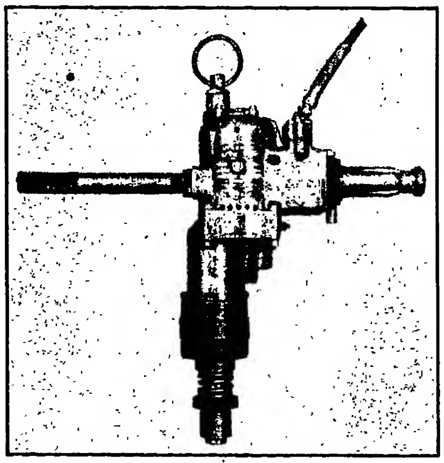

FIG. 8—HIGH-FREQUENCY NUT RUNNER WITH CUSHION CLUTCH

in deck plates on ship work, a high-frequency reamer of 300 rev. per min. synchronous speed reamed 100 holes in 9 min., which was 39 per cent faster than with a compound-wound d-c. reamer weighing 40 per cent more.

In the drilling of metal it has been found that high-frequency drills selected as to proper speed for the size and nature of the holes to be drilled will do the work in one-half the time required by the d-c. or universal drills with their greater speed variation.

So much more work can be accomplished with the high-frequency tool that large numbers of the older types of tools are being discarded. Manufacturers are recognizing the rapidly changing conditions and are willing to scrap the earlier tools to invest in the new equipment necessary, in the shape of frequency converters or motor-generator sets and new wiring in order to gain the advantages of increased production. Due to the transformation to the high-frequency current the cost of power is somewhat more but the individual efficiency of the tools is higher than in the old types of tools. As the cost of current in many industries is only about one-twentieth of the cost of production labor, the great increase in productive capacity made possible by the high-frequency tool compensates many times for the slight increase in cost of current.

The outstanding advantages of high-frequency tools have been so apparent that new applications have been springing up with great rapidity. A few of the tool types and their applications will be described in the following paragraphs.

Fig. 8 shows a nut runner for counterbalanced suspension, equipped with a cushion clutch which is adjustable for various sizes of nuts. This clutch which has multiple jaws, releases at a predetermined load and cannot drop into engagement again until the completion of one full revolution. The jaws are quite shallow and there is considerable angular clearance between the interlocking faces, so that when they drop in after having released, the driving faces come together with considerable speed and due to the yielding effect of the spring which holds them together, they ride up and out of contact with practically no shock to the operator or tool.

Fig. 9 shows a large reamer weighing 50 lb. and handled in most cases by two men. This is capable of 1-5/16-in. reaming in steel at a very rapid rate.

Fig. 10 shows a tool for driving screw studs and at the same time indicating their tightness. The tool is carried in a radial arm which is very flexible and serves to take the torque and support the weight of the tool. It has been the custom in putting in screw studs to drive them part way mechanically and then use a double ended wrench to feel them manually for tightness. This was a double operation and slow.

In the construction shown the tool is free to turn on ball bearings around its spindle axis through an angle of 20 deg. or 30 deg. and this movement is resisted by an

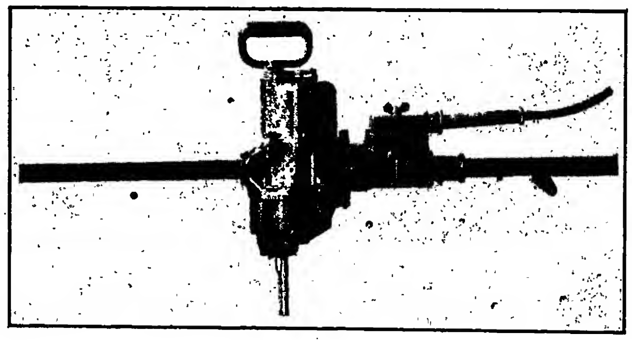

FIG. 9—HIGH-FREQUENCY REAMER

Capacity 1 5/16 in., weight 50 lb.

adjustable weight and lever arm. A so-called solid chuck is generally used which screws over the upper end of the stud and the tool must be reversed to get it off after the stud is driven home. An automatic depth stop, set for the proper length of projection of the stud from the working surface, throws out the driving clutch and stops the tool spindle. The raising of the hand lever at the right engages the reverse clutch and gearing in the tool.

After the tool starts to drive the stud in the tapped hole, the torque developed tends to turn the housing of

the tool against the weight and lever arm shown in Fig. 10, and if this torque is sufficient to lift the weight, an electrical contact is made which causes a green light to appear indicating to the operator that the stud is of the proper tightness. In order to take care of the danger of getting studs too tight, as in cast iron, a second weight and lever are supplied, cooperating with a red light to indicate when the stud is going in too tightly. The excess torque causes the second weight to be lifted and the circuit for the red light to be completed. Current for the lamps is supplied through a small 4-volt transformer.

The radial arm shown in Fig. 10 is also used to carry nut runners as shown in Fig. 8. This relieves the operator of the weight and all shock of driving even when the ordinary solid jaw clutch only is used.

Fig. 11 shows a typical portable grinder for foundry and general grinding. This tool is also furnished with a self-contained angle-gear drive for operating renewable abrasive disks for the sanding of automobile bodies and similar work.

There are many other tool applications which are modifications of those shown. Eight motor sizes comprise the group of tools, Fig. 8 to Fig. 11, with a large number of gear ratios and mechanical combinations.

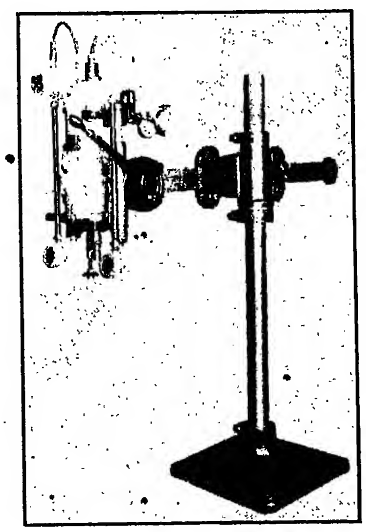

Fig. 10—High-Frequency Stud Setter Mounted on Radial Arm

Supplying the High-Frequency Energy

There are two well-known methods of transforming commercial current to high-frequency current, *viz.*, the frequency converter and the motor-generator.

The frequency-converter can only be used when the primary current is a-c. and consists of special windings in a slip-ring motor frame, the rotor of which is driven backward, usually by an induction or synchronous motor. As satisfactory tool operation depends on good voltage regulation, it has been the aim of the manufacturers to hold within 8 per cent voltage variation, the full-load voltage being 220. The frequency converter has an inherent regulation and the voltage at a given load varies only with the primary voltage.

The motor-generator or alternator provides an entirely new current. The motor can be operated from either direct current or alternating current. If the latter, an exciter will be required for the generator fields. A regulation not to exceed 8 per cent is also desired with this set but it is possible to vary the voltage either manually or automatically by changing the field current of the generator.

The current used for high-frequency tools is three-phase and a cable with four conductors is provided with the tool, terminating in a suitable plug. The fourth conductor is grounded to the housing of the tool and the receptacle in the power line is grounded. This seems to have been satisfactory in the prevention of shocks from grounded windings. It has been suggested that a fourth collector ring be provided on the frequency converter or motor generator to connect to the neutral of the star connected windings and to ground.

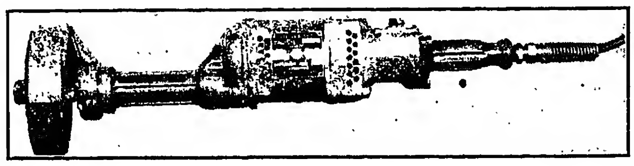

Fig. 11—High-Frequency Grinder

Wheel 6 in. by 1½ in.

The high-frequency tool has withstood rigorous tests over a period of several years and those who are familiar with its capabilities cannot help but feel that it represents the greatest advance made in portable tools since their introduction.

STREET LIGHTING FORMS AIRWAY MARKER

A new street lighting system has been installed on two converging streets in Cheney, Washington, so as to form an arrowhead of light, pointing in the direction of Spokane. Aviators, when flying at night from the West Coast to Spokane, are able to pick up the lights of Cheney and by following the direction of the guiding arrow, find it a simple matter to locate their destination at the large landing field at Spokane.

The new street lighting installation, designed and manufactured by the Westinghouse Company, was donated to the town by Mayor C. D. Martin, as a memorial to his father and mother who were pioneers in that community.

The system consists of 62 ornamental cast iron standards of the Arcadian design with Sol-Lux Luminaires equipped with Bi-lux refractors and 4000-lumen lamps. The Bi-lux refractors, by providing a symmetric distribution of the light, flood the streets with a brilliant illumination readily discernible from a high altitude.

Electric Welding

ANNUAL REPORT OF COMMITTEE ON ELECTRIC WELDING*

To the Board of Directors:

Your Committee on Electric Welding hereby reports the following activities and developments in their field of activity for the fiscal year May 1, 1928–May 1, 1929.

Meetings and Papers

Our Committee arranged for the presentation of two papers, at the March 1929 Regional Meeting held at Cincinnati, namely, one by Professor F. P. McKibben, on *Arc Welding in Building and Bridge Construction;* the second paper by Mr. H. V. Putman, on *Design and Construction of Electrical Machinery Using the Arc Welding Process of Fabrication.*

American Welding Society Activities

The American Welding Society through its several Committees, has prepared tentative codes on: (1) Recommended procedure for fusion welding of pressure vessels; (2) Fusion welding and gas cutting in building construction; (3) Nomenclature definitions and symbols, and is developing a code for welding for pressure piping.

The Fundamental Research Committee of the A. W. S. is carrying on a number of researches headed by able representatives of eight of the leading colleges in the country, who are making studies under a number of subjects, some of which are as follows:

1. Resistance welds in low and high carbon steel rods.
2. Study of welds at elevated temperatures.
3. Effect of current density and microstructures on strength of welds.
4. Study of weld joints by X-rays.
5. Study of the fundamentals of the welding arc.
6. Study of welded rail joints.

The American Welding Society is carrying on a great deal of additional detailed work too extensive to mention in this brief report.

Commercial Activities

Bridge Construction. During the year a ¼-mile line of overhead railroad construction at a prominent steel mill was reconstructed by the addition of 75 tons of steel.

The Public Service Co-ordinated Transport Co. of New Jersey successfully repaired by arc welding two pairs of poney trusses each 86 ft. long, forming a combination trolley and highway bridge spanning the tracks of the Central Railroad of New Jersey and the Lehigh Valley Railroad at Middlesex Borough near Bound Brook, N. J. This was a very unique operation, requiring 50 tons of new steel and is described in *Engineering News Record* of October 25, 1928.

At the present time, the Harahan Bridge at Memphis, Tenn., is being reconstructed and widened which work will involve a total of 250 tons of steel. As an indication of the saving possible in this class of work, we cite the following figures, namely, an average of six bids for riveted reconstruction $15,060 as against an average for the bids by welding construction of $10,750. This represents a saving of 28½ per cent by welded reconstruction as compared with riveted reconstruction work.

Office Buildings, etc. The Homestead Hotel at Hot Springs, Va. has had a 12-story addition made thereto by the arc welding process, the addition involving 550 tons of steel. The principal consideration in this operation was the elimination of noise, which would have disturbed the guests in the old hotel structure immediately alongside of the new structure. It is difficult to put a direct monetary value upon the elimination of excessive noise for such a proposition.

A combination office and bank building, involving 250 tons of steel, was erected at North Tonawanda, N. Y. for the Tonawanda Power Co.

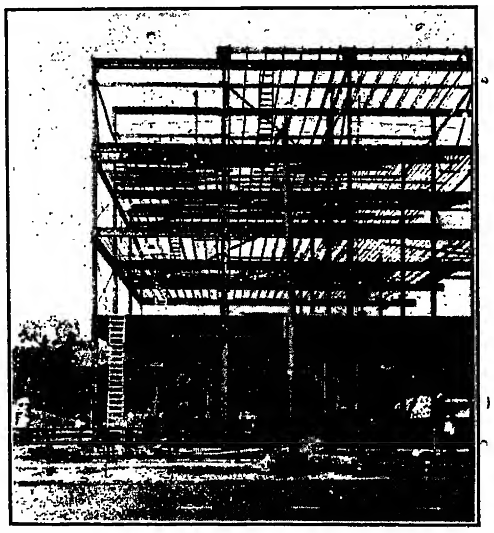

Fig. 1—Cleveland Office Building. Illustrates Decrease in Weight of Columns from the First Floor to the Fourth Floor

An office and store building (Upper Carnegie Bldg.) involving 115 tons of steel was completely erected by the arc welding process, using no rivets or bolts, in the City of Cleveland, Ohio, see Figs. 1, 2, 3, and 4.

Factory Type Buildings. Two buildings of this type were constructed in California for the Southern California Edison Co. at Portersville and Visalia, Calif. A building approximately 50 ft. by 100 ft. was con-

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structed by welding at Los Angeles. Several additional small buildings in California were constructed by welding, with trusses from 40 ft. to 75 ft. span. The American Milling Co. of Omaha, Neb., has built a large hay barn 75 ft by 190 ft., using 100 tons of steel. In central Florida 15 arc-welded buildings have been constructed, principally for citrus packing houses. The largest of

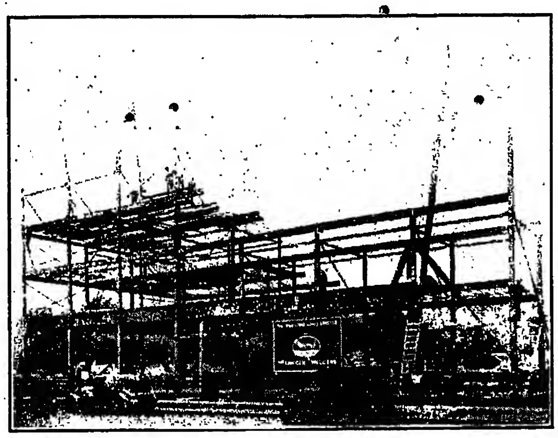

Fig. 2—Shows Framing Partly Erected with 36-In. Girder Welded in Position

these is 117 ft. by 202 ft., containing 200 tons of steel. One building (Fig. 5) is now nearing completion at North Trafford City, Pa., involving 800 tons of steel and floor space in excess of 100,000 sq. ft. A portion of this operation involves a structure three stories in height, the remaining portion being single story construction.

Fig. 3—Detail View Illustrating Welded Joints in 36-in. Girders and Location of Welded Open Beams for Supporting the Floor

Thirty-two municipalities in California and eight in Oregon, Louisiana, Mississippi, Arkansas, and Arizona now have sections in their building codes covering the welding of buildings.

According to the new building code sections for these cities, it is now legal for the Commissioner of Buildings in each place to grant, in the same manner as for riveted frames, permits for the erection of electrically welded steel frame buildings.

Pipe Welding. Several installations for welding two lengths of pipe together in the shop to make approximately 40-ft. lengths out of approximately 20-ft. lengths of pipe have been made during the past year. Also some installations for welding longitudinal joints to produce piping in the shop have also been made.

Considerable progress was made during the past year in electric welding gas and oil pipe lines. The method of making the weld, the size of electrode, and welding conditions have been determined for best results and experience has demonstrated the effectiveness of this procedure. Methods of testing the welds have been worked out so that a minimum of interference with the welding procedure is encountered and yet the tests are very effective for determining the quality of the welds.

The welding of pipe lines of municipal water supply

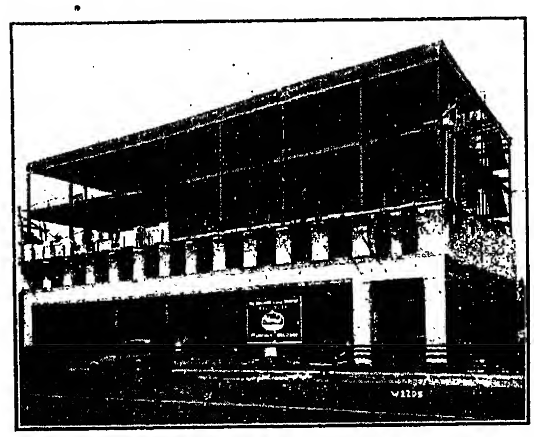

Fig. 4—Shows the Building Partly Completed

has progressed rapidly during the past year. Automatic welding machines and procedure control specifications have been developed for this work. Welding technique and testing methods have been determined to insure uniform results on a production basis. The effect of these developments has been to reduce the cost of pipe lines for city water supply systems.

Between 1400 and 1500 miles of pipe line for carrying oil are now being laid in Texas and the South West.

Figs. 6 and 7 illustrate the welding of pipe on one of these lines.

This line is owned by the Texas Pipe Line Co. and has its sea terminus at Port Arthur and runs 714 miles to a place called Monahans, not far from El Paso, Texas.

This pipe carries oil at a pressure of 800 lb. per square inch.

The process of laying the pipe is to get on an average of five 40-ft. lengths lined up on skids along the same axis so that the ends of the pipes being welded are square with each other and weld these five lengths together, turning the pipe every once in a while so that the welder is welding in a substantially downward position. These

welds are made at the rate of 12 to 14 per day per operator.

Two welds are made on each pipe, a so-called burning in weld and a finishing weld.

One end of each pipe is bell mouthed, and the small end of one pipe is inserted in the large end of the next pipe preparatory to welding.

After the five lengths of pipe are welded into sections the bell mouth end of one section receives the small end of the next section and the two sections are welded together.

This weld is called a "bell-hole weld" and part of this weld must be made overhead. The average rate of making bell hole welds is 8 to 10 per day per operator.

After the pipe is welded, it is lowered into a trench which has been prepared for it and later covered.

The outside of the pipe is protected with a heavy coating of asphaltic material to prevent the earth from

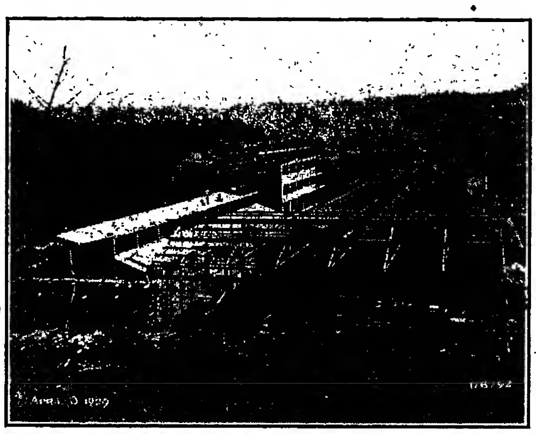

FIG. 5—BUILDING COMPRISES THREE UNITS IN A U GROUP. TRANVERSE UNIT IN FOREGROUND IS 133 FT. BY 60 FT. LONGITUDINAL BUILDING AT LEFT IS 441 FT. BY 62 FT., 140 FT. OF WHICH IS THREE STORIES IN HEIGHT. LONGITUDINAL BUILDING AT RIGHT IS 460 FT. LONG BY 62 FT. WIDE. A COMBINED OFFICE AND SHIPPING BUILDING AT EXTREME END GIVES A TOTAL FLOOR SPACE IN EXCESS OF 100,000 SQ. FT.

coming into contact with the pipe so as to prevent corrosion.

After the pipe is welded it is tested with hydrostatic pressure for tightness, after which the pipe is laid in the trench and covered.

The illustrations show in some detail the process as it is being carried on.

The welding machines are gasoline engines driving welded sets and these may be transported on wagons or may be dragged from point to point by trucks.

Pressure Vessels. During the past year or so two companies have developed special technique and methods for arc welding of heavy steel plate, oil cracking stills, and other high pressure vessels. One of these companies, for example, has manufactured over a thousand vessels using over 70,000 tons of plates averaging about 3 in. in thickness. Excellent ductility and tensile strength are obtained by the methods used by these two companies which employ covered electrodes with special alloys, heavy currents, and annealing of the structure after welding.

Resistance Welding. The use of spot welders, tubing welders, and flash welders has extended rapidly, especially in the automotive field, during the past year. Probably the latest large development in the resistance welding field is that of applying flash welders for producing pipe in commercial lengths, up to about 30 in. in

FIG. 6—BELL HOLE WELDING ON 12-IN. PIPE LINE NEAR WELCH, OKLAHOMA. OBSERVE BENDS IN PIPE DUE TO UNEVEN TERRAIN, WHICH CAUSES NO FAILURES

diameter by 5/8 in. in thickness, requiring several thousand kv-a. of power to make each longitudinal weld.

Machinery Construction. The use of welded machine structures replacing castings has received great impetus during the past year, especially amongst the manufacturers of electrical apparatus. The stator for a 160,000-kw. turbo generator has recently been constructed of arc welded steel. (Figs. 8 and 9.) It is undoubtedly safe to say that at the present time such construction

FIG. 7—TYPICAL FINISHED WELDED JOINT IN 12-IN. PIPE LINE

by several of the leading manufacturers in the United States has reached the point where not less than 2000 tons per month of such fabricated machines are being produced.

Ship Construction. Metal arc welding is being used extensively in the construction of merchant and naval ships. In both cases, the policy pursued is that of a gradual utilization of the process, rather than an attempt to weld the complete ship. In merchant ship con-

struction the object is reduction in cost, while in naval work, the object is to save weight.

International attention has recently focused on arc welding in naval construction because the weight

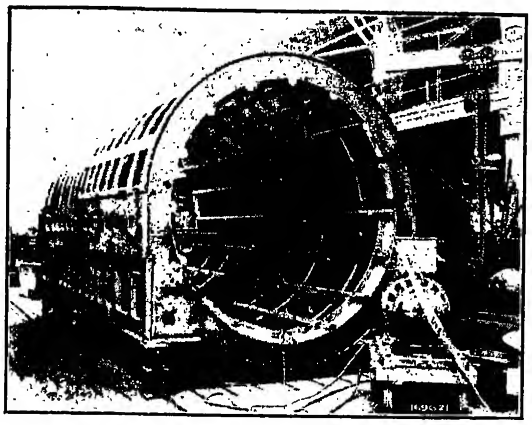

Fig. 8—Frame for 100,000-Kv-a., 3600-Rev. Per Min., Turbo Generator which Weighs Complete 265,000 Pounds and was Shipped as a Unit with Windings in Place. If a Cast Frame had been Used the Weight Would Have Exceeded the Maximum Car Capacity Forcing the Completing of the Machine on Customer's Property Instead of at the Factory

saved by its use materially assisted the German Navy to mount eleven-inch guns on their new 9000-ton cruisers.

The steam ship Virginia, built during the year by the

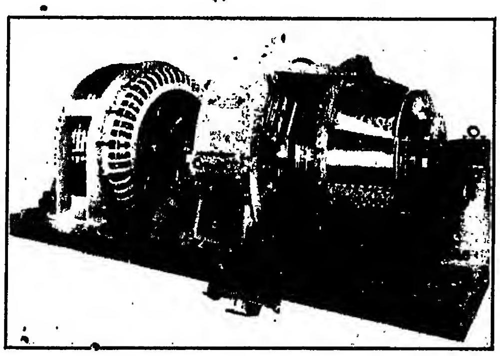

Fig. 9—Shows a Welded Motor-Generator Set the Only Castings Used being the Pedestal Bearings. Even the Brush Rigging for the Generator is of Welded Steel Construction. This Set is Rated at 750 Kw., 900 Rev. Per Min.

Newport News Shipbuilding & Drydock Co. for the Panama Pacific Steam Ship Co., embodied sufficient welding in its construction to require the use of 43,000 lb. of electrode welding wire.

Arc welding has also been used extensively in the construction of the 272-ft. yacht *Viking* for Wm. Baker. In this case, it greatly assisted the architects in obtaining the desired graceful lines.

The Fore River Yard of the Bethlehem Shipbuilding Corp. has constructed a number of bulkheads wherein one row of rivets was replaced by a continuous weld.

The Federal Shipbuilding and Drydock Co. of Kearny, N. J., have recently completed two all-welded channel type scows each 116 ft. long, 34 ft. wide, and 10½ ft. deep.

Miscellaneous. The use of automatic welding equipment has increased materially but to date its possibilities have been appreciated by only a very limited section of industry.

Atomic hydrogen has found many new applications on alloy steels and nonferrous metals. For welding thin sheet steel below No. 16 gage this process has been applied very satisfactorily where smoothness of finish and good ductility are required.

Summary

There are a great many other individual welding applications which might be mentioned but we believe that the above brief résumé summarizes the principal activities in the welding field and will give an insight into welding developments for those who are not directly identified with welding work.

CORRESPONDENCE

STRAY LOSS MEASUREMENTS

To the Editor:

I wish to submit a discussion of Mr. M. C. Holmes' paper on *Separation of Stray Losses in A-C. Generators** as follows:

I believe that Mr. Holmes has given a very clear and correct interpretation of his experimental results. To add some further verification to his conclusions, I may say that we have made several calorimeter tests on turbine generators and found that the load losses at the normal voltage, zero per cent power factor, over-excited condition were substantially the same as those measured on short-circuit. Recently we have made similar tests on some rather large machines at 80 per cent power factor and found the same conditions. In none of these machines was the pole face loss abnormally high, yet, if anything, the load loss at normal voltage was a little greater than that measured on short circuit.

We have made calculations† to determine the axial depth of flux penetration in the armature iron near the ends of the machine, and obtained results comparable to those shown in Fig. 8 of Mr. Holmes' paper.

I should be greatly interested to know how Mr. Holmes determined the volume of iron to which a given measured rate of loss should be attributed in the cases where the iron is thick and the consequent depth of flux penetration might need to be considered; *i. e.*, where the entire thickness of iron probably would not have as high a rate of loss as was measured at the surface by means of the temperature detectors.

J. F. Calvert.

*A. I. E. E. *Jl.*, March 1929, p. 224.

†*Iron Losses in Turbine Generators*, by C. M. Laffoon and J. F. Calvert, A. I. E. E. Quarterly Trans., 48, Part 3, 1929.

Abridgment of

Outdoor Hydrogen-Ventilated Synchronous Condensers

BY ROBERT W. WIESEMAN*

Member, A. I. E. E.

Synopsis.—Hydrogen is an excellent cooling medium for high-speed rotating electrical machinery. When it is substituted for air, a machine can be operated at a higher load with the same temperature rise and the windage loss is decreased to one-twelfth. Furthermore, since no oxidation can take place in this type of machine, the life of the insulation is increased and short circuit and corona troubles are very materially reduced. The machine is especially quiet, and it can be placed out of doors without increased expense.

The first commercial application of hydrogen cooling for electrical machinery was made on a 12,500-kv-a. outdoor synchronous condenser. Another outdoor hydrogen-cooled condenser designed along these lines rated 20,000 kv-a., is also in operation. Both condensers were placed in service in 1928 and their performance has been very satisfactory. This paper describes the construction of the machines and reviews the advantages and disadvantages of hydrogen cooling.

* * * * *

I. Introduction

Advantages in Ventilating a Machine with Hydrogen

The characteristics of hydrogen gas, which makes it desirable as a cooling medium for high-speed rotating electrical machinery, are as follows:

Low Density of Hydrogen. Hydrogen is a colorless, odorless, tasteless gas whose density is only 7 per cent that of air. The windage loss of a rotor is approximately proportional to the density of the gas in which it rotates. Thus, the windage loss of a rotor running in an atmosphere of pure hydrogen is only 7 per cent of the air loss. It was found to be entirely practical to maintain a gas mixture in a machine of 99 per cent hydrogen and 1 per cent air, etc., and so a windage loss of only 8 per cent of the air loss is realized. The decreased windage loss also decreases the amount of heat to be removed from the machine, and the size of the surface cooler can be reduced when hydrogen is used as a cooling medium. The bearing friction loss is the same in hydrogen as in air.

High Thermal Conductivity of Hydrogen. Hydrogen conducts heat about seven times better than air and the specific heat of a gram of hydrogen is about 14.5 times that of a gram of air. Consequently, heat passes across the small spaces in the insulation and between the laminations, etc., much more readily than with air cooling; and so the internal copper temperature, for a given surface temperature, is less in hydrogen than in air.

High Forced Heat Convection of Hydrogen. In an atmosphere of hydrogen 30 per cent more heat can be transferred from heated surfaces than in air with the same surface temperature drop. Furthermore, when the hydrogen comes in contact with a surface cooler, more heat can be transferred to the cooler than with air. This again enables a smaller surface cooler to be used; or with the same cooler a lower cooling medium temperature is realized, and the internal temperature of the coil is still further reduced. The bearing temperature is also less in hydrogen than in air.

The reduction of windage loss, the increased thermal conductivity and forced heat convection of hydrogen result in an increased output of 25 per cent or more, depending upon the hydrogen pressure used, the type of ventilation employed, the degree of saturation in the magnetic structure, and the stability required.

No Combustion Possible in an Atmosphere of Hydrogen. There is no oxygen or dirt present in the machine, and, consequently, a combustion cannot take place. This eliminates the need of fire extinguishing apparatus. The burning of iron and insulation following a ground or short circuit is reduced to a minimum. The insulation retains its flexibility, and its life therefore is greatly increased. The bearing lubricating oil remains clean and it does not oxidize or sludge so readily as in an air cooled machine.

Detrimental Effect of Corona Reduced to a Minimum. The thickness of the armature coil insulation is governed partly by the high-voltage gradient and the formation of corona in the minute spaces of the insulation. Tests have demonstrated that the damage caused by corona is practically absent in an atmosphere of hydrogen.[1] Not only will this increase the insulation life, but it will allow a thinner insulation to be used or a greater factor of safety to be secured. These factors will not only make it easier to build machines of present day voltages, but they will make it possible to employ higher voltages in the future.

Finally, the absence of corona damage to varnished fabric insulations will permit their use on high-voltage machines with a substantial decrease in cost. The greater impulse voltage strength of varnished fabric as compared with mica insulation thus gives the hydrogen-cooled machine a further advantage for installations where high-voltage surges are likely to be experienced.

Outdoor Operation. At practically no increase in

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1. For references, see Bibliography.

cost a hydrogen-ventilated machine can be made suitably weather-proof for outdoor operation. This effects a great saving in building expense.

Quiet Operation. The windage noise of a totally enclosed hydrogen-cooled machine is very much less than that of an air-cooled machine. Thus, a hydrogen-cooled machine is exceptionally quiet and it can be placed outdoors in a residential district where a noisy machine would be very objectionable.

Disadvantages in Ventilating with Hydrogen

Safety Precautions. When hydrogen cooling was first proposed, some difficulty in preventing accidental explosions was anticipated. The increasing familiarity with the problem and the extensive use of hydrogen for many indistrial purposes, such as brazing, annealing, welding, etc., indicate that there should be no difficulty with this problem. The Schenectady factory of the General Electric Company uses 30,000,000 cu. ft. of hydrogen per year without experiencing any difficulty from this source. Every city has one or more gasometers containing many thousands of cubic feet of gas which though not explosion-proof give practically no trouble. The following table gives the stored energy in a steam boiler, in a large turbine-generator rotor, and in the gas of a hydrogen-ventilated synchronous condenser when it contains the most explosive mixture of air and hydrogen:

	Stored energy ft-lb.	Per cent
Steam boiler 2000 boiler hp.	$25,000 \times 10^6$	100
Large turbine-generator rotor	300×10^6	6.0
Hydrogen-ventilated machine containing 1000 cu. ft. of the most explosive mixture of air and hydrogen at atmospheric pressure	70×10^6	1.4

It is quite evident that a hydrogen-ventilated synchronous condenser has very much less potential explosive force than other apparatus in common use.

A mixture of hydrogen and air will not explode if the hydrogen content, by volume, is more than 70 per cent or less than 10 per cent. If a machine is scavenged with carbon dioxide before it is filled with hydrogen, no explosion can take place when it is started for the first time. The hydrogen pressure in the machine is automatically maintained slightly above atmospheric pressure. This prevents air from leaking into the machine, and eventually the hydrogen purity will reach that of commercial hydrogen which is usually around 99 per cent. It has been found that a hydrogen purity of 98 per cent can be obtained in a few hours after a machine is filled with hydrogen. A hydrogen purity indicator can be made to ring an alarm if the purity falls below normal. A fan pressure gage calibrated to read hydrogen purity gives an instantaneous reading of the hydrogen purity in the machine when it is in operation. Thus, the possibility of an explosion is very remote if the machine is given ordinary supervision.

Increased Disassembly Expense. If a hydrogen-ventilated condenser must be disassembled for repairs, more time will be consumed and more expense will be involved than with a standard air-cooled machine. On the other hand, it should not be necessary to dismantle the hydrogen-ventilated machine so often because of its longer insulation life, its lower bearing and internal coil temperature, and the absence of dirt. It is believed, therefore, that the total maintenance expense over a period of years will be less for the hydrogen-cooled machine.

II. Hydrogen Cooling can be Easily Applied to a Synchronous Condenser

It is unnecessary to have the shaft of a condenser extend through the gas-tight shell as in the case of a turbine generator, and so a seal[2] of any kind around the shaft is not required. With this arrangement, the construction of the machine is simplified because the entire machine, including the bearings and shaft, can be enclosed in a gas-tight shell.

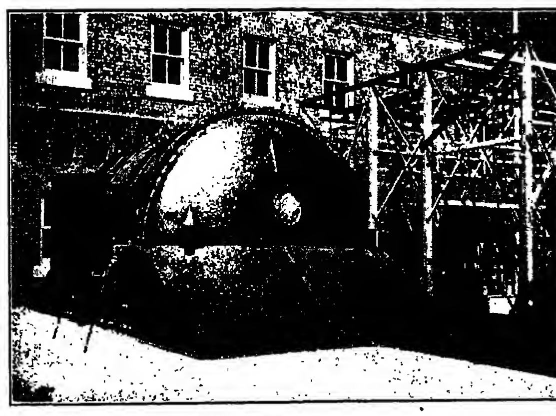

Fig. 1—The First Outdoor Hydrogen-Ventilated Synchronous Condenser, 12,500-Kv-a., 900-Rev. per Min., Three-Phase, 60-Cycle, 13,800-Volts. New England Power Co., Pawtucket, R. I.

III. Description of Outdoor Installation

Fig. 1 shows the 12,500-kv-a. hydrogen-ventilated synchronous condenser completely installed at the Pawtucket, R. I. Substation of the New England Power Company. This condenser is the first of its kind ever built. It is located out of doors without any protection from the weather, but is placed over a pit which is made weather-proof by a substantial sheet-iron covering. Along side of the condenser are located the switches, starting compensator, transformers, and lightning arresters. Fig. 3 is a sectional view of the machine. These views show the semi-circular surface coolers, the bearing housing and its fabricated support, the high-voltage armature terminals, the collector housing, and the construction of the gas-tight frame. The bearings

can be filled with oil and drained without dismantling the machine or losing any hydrogen.

The 20,000-kv-a. condenser located near Charleston, W. Va., at the Turner Substation of the Appalachian Electric Power Company is also placed out of doors and it has the same design as the 12,500-kv-a. condenser except that its capacity is higher. The field collector is located in a small housing which is bolted to the end head.

In the weather-proof pit beneath the condenser are located the cooling water circulating pump, the oil pump for filling the bearings and furnishing high pressure oil for starting, the hydrogen supply tanks, the hydrogen pressure gage, the indicating thermometers, the automatic hydrogen pressure control, the rotor fan pressure gage for indicating the hydrogen purity when the machine is in operation, the thermal cell of the hydrogen purity indicator which indicates the hydrogen purity at all times, and the various valves for controlling the water, oil, and hydrogen.

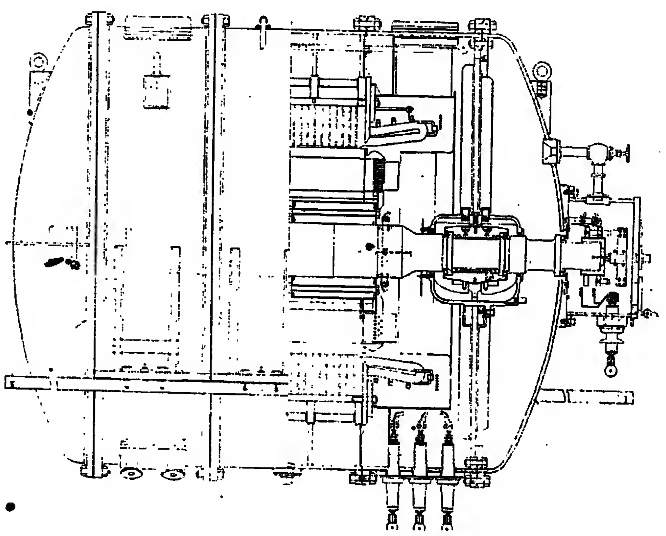

Fig. 3—Sectional View of the 12,500-Kv-a. Hydrogen-Ventilated Synchronous Condenser

IV. Explosion-Proof Frame

The stator frame consists of three sections and two heads bolted together as shown by Fig. 3. The main joints of the frame are gasketed gas-tight and they have practically no hydrogen leakage. The large middle section holds the armature punchings and windings and the two smaller sections hold the internal surface coolers and bearings. The frame is fabricated entirely from steel plate. The elimination of castings, which are sometimes porous, is not only in keeping with present day dynamo machine construction, but it also insured minimum hydrogen leakage.

In order to minimize the effect of an explosion resulting from careless operation, these condensers were provided with a cylindrical explosion-proof frame designed to resist the disruptive force of the most explosive mixture of hydrogen and air at atmospheric pressure. The frame of the 12,500-kv-a. condenser without windings, coolers, and piping, was filled with the most explosive mixture of air and hydrogen, and the gas was ignited with a spark plug. No damage resulted from the explosion which developed a maximum pressure of 85 lb. per sq. in. as recorded by an instantaneous pressure recorder. If the machine had been completely assembled with all of the various metallic parts, especially the coolers, the pressure would have been only about 50 lb. per sq. in. This test also showed that an explosion would have no detrimental effect on the insulation. It is very unlikely that the gas in the machine will ever reach the most explosive mixture of air and hydrogen of 5 to 2 by volume. For any other gas mixture, the explosive force would be very much reduced. The theoretical pressure of 180 lb. per sq. in. with an air-hydrogen explosion could be obtained only if no heat were absorbed by the explosion chamber and its contents.

VII. Hydrogen Ventilation

Each end of the frame contains two-semi-circular surface coolers. The cooler heads can be removed and the tubes cleaned without dismantling the machine or losing any hydrogen. The four cooler units are piped in multiple, and air vents and drain valves allow the coolers to be thoroughly drained to prevent any water in the cooler from freezing in the winter if the machine is not in use.

The rotor poles and fans force the ventilating gas through the stator ducts to the back of the stator frame. Then the gas passes through the semi-circular coolers and is returned to the rotor and recirculated. Provision is made for ventilating the collector housing by circulating hydrogen through the housing by means of two pipes. Two dial thermometers indicate the temperatures of the ventilating gas before and after it passes through the cooler. If the temperature of the gas leaving the cooler exceeds 40 deg. cent., the thermometer rings an alarm. Indicating thermometers also ring an alarm if the bearing temperature exceeds 70 deg. cent.

VIII. Hydrogen Leakage

An automatic pressure regulating switch and valve maintain the hydrogen in the machine always slightly above atmospheric pressure to prevent air from leaking into the shell. The hydrogen pressure in the machine varies with its internal temperature. The average pressure is around ½ lb. per sq. in. and the leakage of the machine itself at this pressure is about 6 cu. ft. per day which costs around 10 cents. The hydrogen purity indicator wastes a small amount of hydrogen for its thermal analysis. Thus, the total hydrogen cost is very small, from 15 to 20 cents per day, depending upon how much is used by the hydrogen purity indicator.

IX. Increased Output

The excellent cooling properties of hydrogen enable a given machine to operate at an increased output at the same temperature rise. If the hydrogen pressure is increased above atmospheric pressure, the output can be further increased. Numerous heat runs were made in which the hydrogen pressure was increased in steps up to 25 lb. per sq. in. These tests indicated that a hydrogen pressure of 15 lb. per sq. in. gave the best results. If the pressure is increased above this amount, the windage loss increases appreciably and the gain in output is not so marked.

The following table shows how the output of salient-pole high-speed condensers increases with the same temperature rise when hydrogen is used for the cooling medium:

Cooling medium	Machine output
Air at atmospheric pressure	100 per cent
Hydrogen at a pressure slightly above atmospheric pressure	125 per cent
Hydrogen at a pressure of 15 lb. per sq. in. above atmospheric pressure	140 per cent

Naturally, these figures will vary with different types of machines. The field winding is usually the limiting feature because it is more difficult to ventilate, and magnetic saturation and stability impose more limitations on the rotor than on the stator.

X. Decreased Losses

The introduction of hydrogen into a machine reduces the rotor windage loss to about eight per cent of its loss in air. The following table shows the saving in windage loss of the two condensers:

Machine capacity kv-a.	Reduction of windage loss accomplished by hydrogen
20,000	85 kw. (0.42% of machine rating)
12,500	51 kw. (0.41% of machine rating)

The internal copper temperatures are less with hydrogen, and so the copper losses will be slightly reduced. Fig. 7 shows the total losses of the 20,000-kv-a., three-phase, 60-cycle, 11,500-volt hydrogen-ventilated condenser at various loads. The losses are given for air at atmospheric pressure, for hydrogen slightly above atmospheric pressure, and for hydrogen at 15 lb. per sq. in. At 20,000 kv-a. the total loss of this condenser in hydrogen is only 1.5 per cent.

XI. Cost of Outdoor Installation

The initial cost of any new type of apparatus is usually high, and the development of hydrogen-cooled machines has not yet reached the point where its cost alone is the same as that of a standard air-cooled machine of the same size. The gas-tight construction, the water coolers, and the auxiliary control features naturally increase the cost which is partly offset by the increased rating obtainable. However, the value of the improved efficiency due to the lower windage loss (Fig. 7) will probably prove the deciding factor in any cost comparison. The capitalized value of the two per cent losses of a synchronous condenser is about the same order of magnitude as the first cost of the condenser installation, so that any reduction in the losses is of the same economic value as an equal reduction in cost. Thus, when decreased losses, increased capacity, lower internal temperatures, reduced fire risk, longer insulation life, cleanliness, quietness, and saving in building expense (outdoor operation) are capitalized, a large hydrogen-ventilated machine has a real economic justification.

Conclusions

The results obtained on these two hydrogen-ventilated synchronous condensers to date have been very encouraging and three more machines, rated 15,000 kv-a., are under construction. Not only have the hydrogen features of the machines performed satisfactorily, but during the past winter the machines have operated successfully out of doors with no protection from the weather. Thus outdoor synchronous condensers, whether air or hydrogen cooled, should give reliable service at a reduced overhead expense.

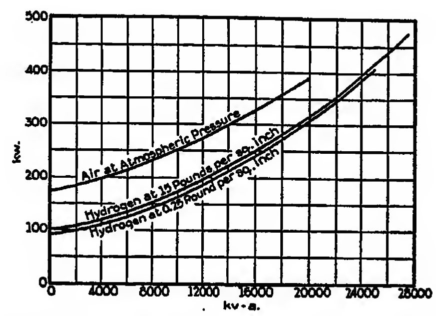

Fig. 7—Total Losses of the 20,000-Kv-a., 11,500-Volt, 60-Cycle. Hydrogen-Ventilated Synchronous Condenser

Electrical manufacturers are constantly striving to improve the efficiency and the ventilation of rotating machinery. High-grade magnetic steel, transposed armature windings, correct magnetic structure shapes and proportions, improved rotor fans and ventilating ducts, thinner and more compact insulation, etc., all tend to reduce the losses and the size of a machine. However, these refinements have been worked over so exhaustively that further improvements in performance characteristics by these means will perhaps be relatively small. Any appreciable gain must come by the way of a radical change in the machine structure, materials, or ventilating medium. Hydrogen cooling is one of these radical departures from tradition which opens new avenues of progress and rotating machines with 99 per cent efficiency may soon be a reality.

Acknowledgment

The cordial cooperation of the New England Power

Company and the Appalachian Electric Power Company in obtaining the various tests on these hydrogen-ventilated synchronous condensers is greatly appreciated.

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Abridgment of

A New Type of Hot Cathode Oscillograph its Application to the Automatic Recording of Lightning and Switching Surges

BY R. H. GEORGE*

Associate, A. I. E. E.

***Synopsis.**—This paper presents a new general purpose type of hot cathode oscillograph which employs a new electrostatic method of focusing the beam. This oscillograph will operate at any beam potential from 500 to 20,000 volts or more, and at any gas pressure below 30 microns. High photographic sensitivity at medium voltages is attained by the use of a high-intensity beam.*

A portable form of the oscillograph for recording lightning surges on transmission lines is described, together with circuits by means of which the lightning surge automatically starts the beam in from ½ to ¼ microseconds after the surge voltage begins to rise from zero. This oscillograph was put into operation on one of the 140-kv. transmission lines of the Consumers Power Company of Jackson, Michigan, on August 27, 1928.

* * * * *

Introduction

With the interconnection of large power systems and with the rapid developments in the art of radio and carrier-current communication have come new problems, many of which involve the study of high-frequency phenomena beyond the range of the ordinary Duddell oscillograph. Consequently the importance of solving such problems has stimulated active interest in the development and application of the cathode ray oscillograph,† a device capable of recording extremely high frequency phenomena. As a result there have been developed within the last decade, some three or possibly four general types of cathode ray oscillographs as follows: the low voltage hot cathode type of the Western Electric Company,[1] the medium-voltage hot cathode type of Wood,[2] the high-voltage cold cathode type of Dufour,[3] Norinder,[4] the General Electric Company,[5] and more recently the high-voltage hot cathode type of Rogowski.[6]

This paper presents a new general purpose type of hot cathode oscillograph, capable of operating at any potential from 500 volts to 20,000 volts or more, and a special portable form for lightning recording. The object in developing the general purpose oscillograph was to produce one having sufficient flexibility to combine so far as possible the desirable qualities of the previous types of cathode ray oscillograph and yet be simple and reliable in operation.

Salient Features of the New Oscillograph

Some of the outstanding features of the new oscillograph are as follows:

1. The use of a special hot cathode electron gun which makes possible automatic starting and stopping of the beam for recording lightning surges on transmission lines.

2. The use of a new electrostatic method of focusing the beam, effective at any pressure from about 30 microns down to the lowest pressure obtainable with a mercury pump.

3. The entire beam passes through the high-voltage anode, thus eliminating the problem of anode heating.

4. Bakelite is used for insulating the high-voltage cathode and the deflecting plates, thus reducing the danger of breakage.

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†For a history of the development of the cathode ray oscillograph with complete bibliography see "Measurements in Electrical Engineering by Means of Cathode Rays," by J. T. MacGregor-Morris and R. Mines, *Journal of I. E. E.*, Nov., 1925, Vol. 63, p. 1056.

1. See Bibliography.

Presented at the Regional Meeting of the Middle Eastern District, Cincinnati, Ohio, March 20-22, 1929. Complete copies upon request.

5. The deflecting plates are adjustable from outside the vacuum which makes it possible to vary the deflection sensitivity if desired.

6. All parts are readily accessible and easily replaced in case of damage.

General. The method of attack in the design and development of the general purpose oscillograph has been to gain the necessary photographic sensitivity through the use of a high-intensity beam at a minimum beam voltage. The principal problem, then, has been one of devising satisfactory means for producing and focusing a high-intensity beam over a sufficient range of beam voltages to insure the necessary photographic sensitivity. It is the solution of this problem which constitutes the major contribution of this paper.

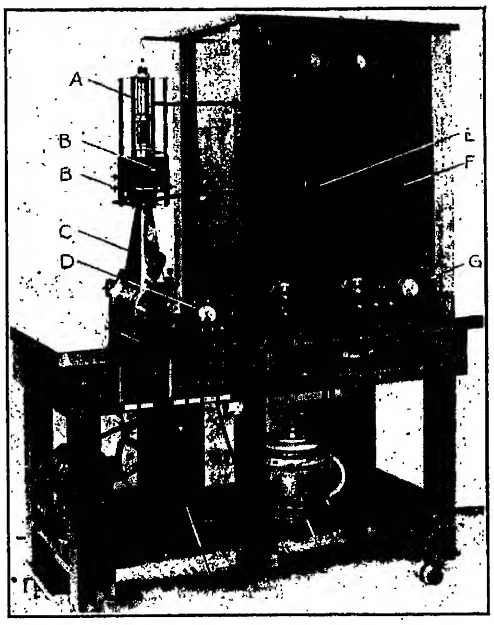

FIG. 1—PORTABLE HOT CATHODE OSCILLOGRAPH FOR SURGE RECORDING

A. Electron gun housing.
B. Terminals of deflecting plates.
C. Oscillograph bell.
D. Vacuum gage.
E. Gun voltage control.
F. Cathode voltage control.
G. Timing oscillator.
H. Vacuum pump.
I. Drying chamber for films.

Description of the Oscillograph. A general idea of the appearance of the oscillograph may be gained from Fig. 1, which shows a portable outfit designed especially for recording lightning surges. Fig. 2 illustrates the internal construction.

The general purpose laboratory type of instrument is provided with both a rotating film drum and plate drum. The film drum takes 5 in. by 30 in. with which the equivalent of a continuous record 140 in. in length can be obtained. The plate holder takes six 4- by 5-in. plates. The portable type shown in Figs. 1 and 2 is made much more compact to reduce the volume, and takes 5-in. roll film. The oscillograms are $2\frac{1}{2}$ in. by 5 in., although in a more recent design the oscillograms will be $3\frac{1}{2}$ in. by 5 in. If special long rolls are used, as many as 100 exposures can be taken with one loading.

The Electrostatic Method of Focusing the Beam. The most important feature of the oscillograph illustrated is the electrostatic method of concentrating and focusing the beam, which is effective at any beam potential from 500 volts to a least 20,000 volts.

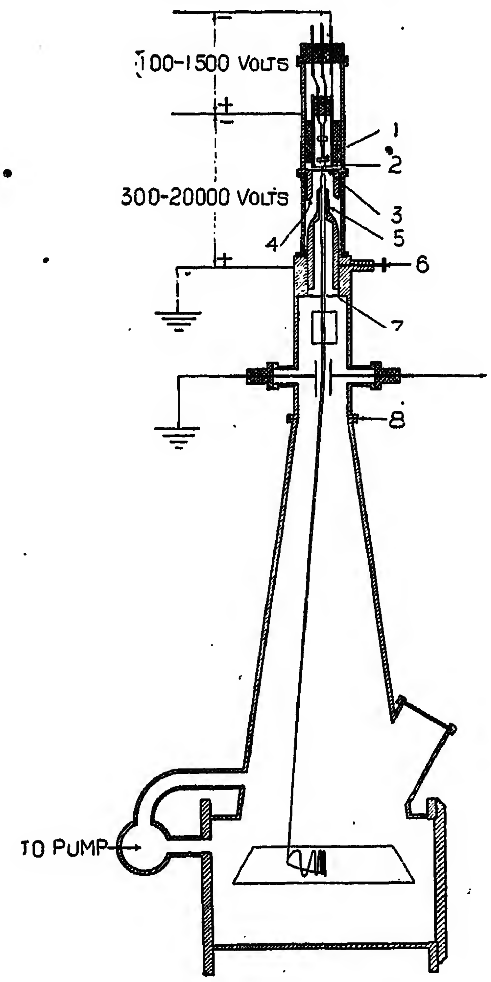

FIG. 2—DIAGRAMATIC SCHEME OF THE PORTABLE OSCILLOGRAPH

(1) Ribbon filament.
(2) Filament shield.
(3) Positive plate.
(4) Cup-shaped cathode.
(5) Cylindrical anode.
(6) Screw for raising and lowering anode.

Referring to Fig. 3, the beam from the filament (1) is concentrated and brought to a focus at the hole in the plate (3), by properly proportioning the spacing between the filament (1), the filament shield (2), and the plate (3), with respect to the size of the hole in (2), to produce a rapidly converging field between the filament and plate. After passing through the small hole in the plate into the high potential cathode (4) the beam diverges at first as indicated by the dotted lines,

Fig. 3, due to the momentum received from the converging field in the gun.

The cathode (4) and the anode (5) are so shaped that the high-potential field converges toward the anode. Therefore the electrons in falling through this field are not only accelerated in the direction of the anode but are given a component of velocity toward the center of the beam. If this inward radial component of momentum of the electrons is great enough to overcome their force of repulsion, the beam can be brought to a focus. It is therefore apparent that the distance from the cathode at which the beam will come to a focus depends upon the diameter of the beam when it starts to converge, hence the divergence of the beam on

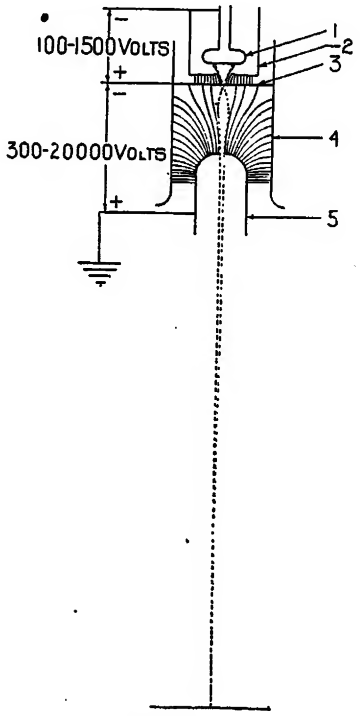

Fig. 3—Diagram Showing Method of Focusing the Beam

entering the cathode. This fact also necessitates the use of a large hole in the anode.

Since the time through which the mutual repulsion of the electrons in the beam acts, depends upon the velocity of the beam and consequently upon the beam potential, it is necessary to be able to vary the radial component of the high potential field in order to focus the beam. This is done by raising or lowering the anode by means of a rack and pinion operated by the knurled head (6), Fig. 2.

Application of the Oscillograph

A. With Continuous Beam.

A steady beam can be produced and maintained for hours, if necessary, at any beam voltage from 500 volts to 20,000 volts, depending upon the deflectional and hotographic sensitivities required.

continuous beam permits study of the various forms of Lissajous figures, such as power-loss loops including magnetization and dielectric loss curves, vacuum tube characteristics, frequency checking, etc.

Fig. 4 represents a section of a voice record taken with the laboratory oscillograph at a beam voltage of approximately 2500 volts. The timing is indicated by the

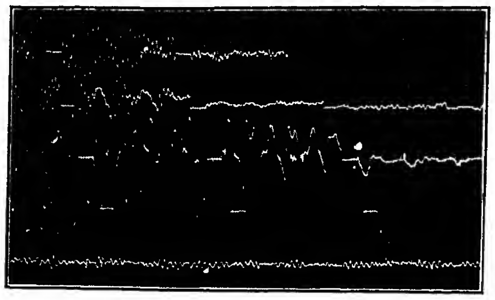

Fig. 4—Voice Record Taken with 2500-Volt Beam

dashes which occur at intervals of 1/60 of a second. The diameter of the beam was less than 1/2 millimeter.

Fig. 5 is a 500,000-cycle wave having an amplitude such that the beam was traveling at the rate of 100 kilometers (62 mi.) per second when crossing the zero axis. This oscillogram was taken with a 10,000-volt beam.

B. Recording Lightning Surges on Transmission Lines.

It was at the request of the Consumers Power Company of Jackson, Michigan that the writer, under the auspices of the Engineering Experiment Station of Purdue University, undertook the design of a cathode ray oscillograph for recording lightning surges on transmission lines. This cooperative project resulted in the construction of the portable oscillograph illustrated by Fig. 1.

The recording of lightning surges presents a difficult

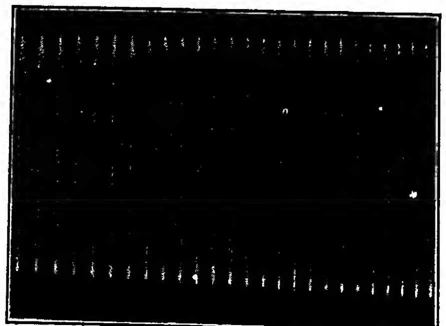

Fig. 6—500,000-Cycle Wave Taken with 10,000-Volt Beam

problem, in that the time at which a surge will occur cannot be predetermined. Therefore the oscillograph beam must either remain on continuously, or means must be provided whereby the transient to be recorded automatically starts the beam.

Fig. 5 represents the circuit diagram for the portable oscillograph including a circuit for automatically initiating the beam by applying plate voltage to the

electron gun. With this circuit the plate or beam current of the electron gun must pass through one of the two vacuum tubes inserted between the gun voltage supply and the filament. Therefore the beam can be stopped by applying a sufficient negative bias to the grid of the vacuum tubes to prevent the flow of

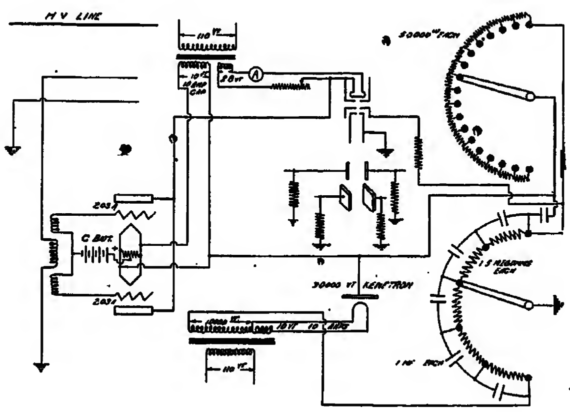

FIG. 7—CIRCUIT FOR AUTOMATICALLY STARTING BEAM BY SWITCHING PLATE VOLTAGE OF ELECTRON GUN

plate current. Then in order to initiate the beam, it is necessary to apply a small positive impulse to the grid of one or both tubes, after which the time required for the beam to build up depends upon the rate at which the electron gun can be charged as a condenser.

The circuit for producing the positive impulse on the grid of one of the vacuum tubes has some desirable

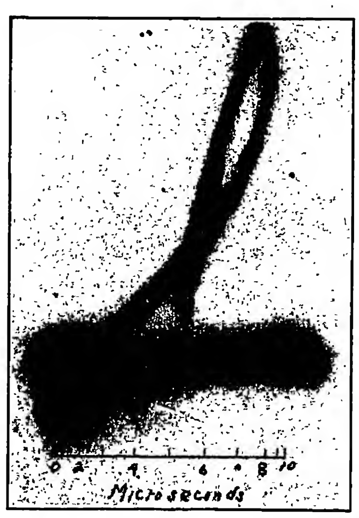

FIG. 11—LIGHTNING GENERATOR IMPULSE WHICH AUTOMATICALLY STARTED BEAM

characteristics which may not be evident. The first important requirement to be met is that the surge to be recorded must produce a positive impulse on the grid of one of the tubes regardless of the polarity of the surge. This is most readily accomplished by an inductively coupled circuit which also has the advantage that the antenna of the dividing condenser can be insulated from the high-voltage direct current of the oscillograph.

A rather unexpected advantage of the inductively coupled circuit comes from making the inductance such that the inductive reactance of the antenna circuit is small compared to the capacity reactance. This permits the charging current in the antenna circuit to reach its maximum well in advance of the maximum voltage of the surge, and since the voltage drop across the inductance is proportional to the rate of change of current, it therefore reaches its maximum ahead of the current. The inductance is, however, the primary of an air-core transformer, therefore the voltage induced in the secondary or grid circuit also reaches its maximum ahead of the current in the primary.

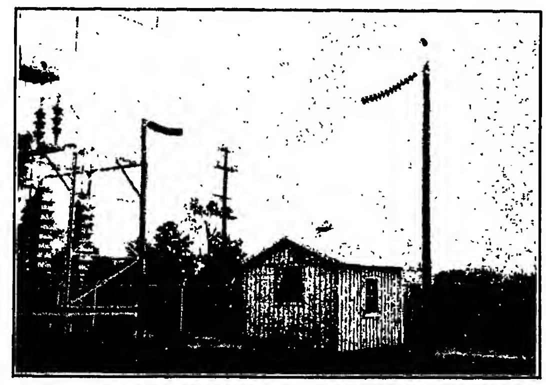

FIG. 12—INSTALLATION OF CATHODE RAY OSCILLOGRAPH ON 140-KV. LINE OF THE CONSUMERS POWER COMPANY

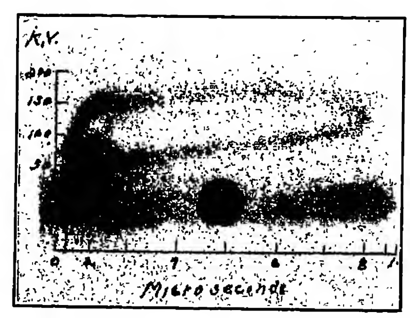

FIG. 13—LIGHTNING SURGE RECORDED ON 140-KV. LINE OF THE CONSUMERS POWER COMPANY

Since klydonograph records indicate that lightning surges may reach a maximum in from one to ten microseconds, this circuit is capable of getting the beam under way in time to record practically the entire wave.

Fig. 11 shows a record taken of a lightning generator wave in which the beam was automatically started by the surge. The surge was applied at right angles to a 50,000-cycle timing wave.

The portable hot cathode oscillograph, (Fig. 1), employing the automatic beam starting feature, was put into operation on a 140-kv. line of the Consumers Power Company of Jackson, Michigan at their Blackstone Substation on August 27, 1928. Fig. 12 shows this installation.

This oscillograph is entirely self-contained with the

exception of the power supply which is taken from a 110-volt 60-cycle source.

With well dried film the oil pump alone will produce a workable vacuum in approximately three minutes. The film holder is daylight loading and takes a standard No. 104 film.

Fig. 13 shows a 170-kv. surge which occurred during a distant lightning storm.

Development work is being continued along the following lines:

1. Further increasing the beam intensity.
2. Focusing still higher voltage beams.
3. The production of a linear time axis for lightning records.
4. Making the recording of lightning surges more nearly automatic.

CONCLUSION

It is felt that this oscillograph will prove particularly useful in laboratories where a wide variety of work is handled as well as in field investigations.

The author wishes to express his sincere appreciation to Professor C. Francis Harding for his continued interest and encouragement as well as making the work possible, to Mr. J. W. Raleigh for valuable assistance in the early stages of the work, and to Mr. J. R. Eaton of the Consumers Power Company for many valuable suggestions.

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Abridgment of

Telephone Circuits for Program Transmission

BY F. A. COWAN[1]
Member, A. I. E. E.

Synopsis.—Networks of telephone circuits which are extensively used in the transmission of programs to broadcasting stations are described in this paper. Certain stages in the development of these networks are considered and the general requirements for satisfactory transmission at the present time are enumerated. The arrangements of the networks as well as the procedures used in setting up and maintaining them are discussed.

* * * * *

MUCH of the phenomenal growth and present excellence of radio broadcasting has resulted from contributions made by associated branches of the electrical art. Of these contributions perhaps none has had a greater effect than the introduction of the program transmission wire networks, which make chain broadcasting possible. Broadcasting had hardly emerged from the novelty stage before the need for programs presenting music of the highest grade, speeches by prominent people, and descriptions of sports events of sectional or national interest became evident. It was further recognized that in addition to providing programs of this character, it would be desirable to broadcast the programs simultaneously from a number of stations. These conditions established a demand for means of picking up selected program material and transmitting it to broadcasting stations scattered throughout the country. For this transmission, wire lines have proved to be very satisfactory and are in general use for this purpose.

Prior to the general development of radio broadcasting, the Bell System had, incident to other developments, worked out the problems involved in such transmission, and on numerous occasions had set up interconnections of radio telephone stations and public address systems which were substantially the same as those required for broadcast program transmission. The telephone companies, therefore, were able to meet this new requirement for communication service early in the development of radio broadcasting. One of the first occasions of this type was in the fall of 1922, when the description of the Chicago-Princeton football game at Chicago was broadcast through station WEAF, then operated by the American Telephone and Telegraph Company, at New York City. Another of the earlier services was the interconnection of six broadcasting stations, one of which was in Dallas, for the simultaneous broadcasting of President Coolidge's first address to Congress on December 6, 1923. Since that time there has been a steady and continuing growth in this service until there are now furnished by the Bell System more than 30,000 mi. of regularly established program circuits which connect in various combinations and at various times over 125 radio broadcasting stations covering the entire United States. The various stages of this development up to the establishment of a 15 station part-time network in the latter part of 1924 are described in a paper by Messrs. Foland and Rose, published in the January 1925 issue of *Electrical Communications.*

1. Long Lines Dept., American Telephone and Telegraph Co., New York, N. Y.

Presented at the Regional Meeting of the South West District of the A. I. E. E., Dallas, Texas, May 7-9, 1929. Complete copies upon request.

The first multi-station network for which special equipment was provided at key points on a permanent basis was initially called the "red network" for no other reason than that those cities which were to be connected were indicated on a chart by red lines, and a memorandum on the arrangements for the circuits referred to them as the "network shown in red." As other networks came into being, the convenience of a short color name for differentiating between them resulted in a rather general use of this form of designation within the telephone companies, and it was not long before this nomenclature had spread among the various broadcasting companies.

Initially, this network service was confined mainly to evening hours and to sections where telephone message circuits could be obtained, but it soon became apparent that more time would be required than could be furnished on this basis, and as rapidly as possible, program circuits specially provided for this purpose were made available on a larger scale. The routes of the regularly established program circuits of the Bell System in the United States on March 15, 1929, are shown on Fig. 1. These regular networks are supplemented by special circuits which are established for the transmission to the network control points of programs picked up at the location of event of particular interest or national importance. Also, on certain occasions, several of the chains have been merged into one, thereby forming a network of stations which effectively makes the United States into one large auditorium.

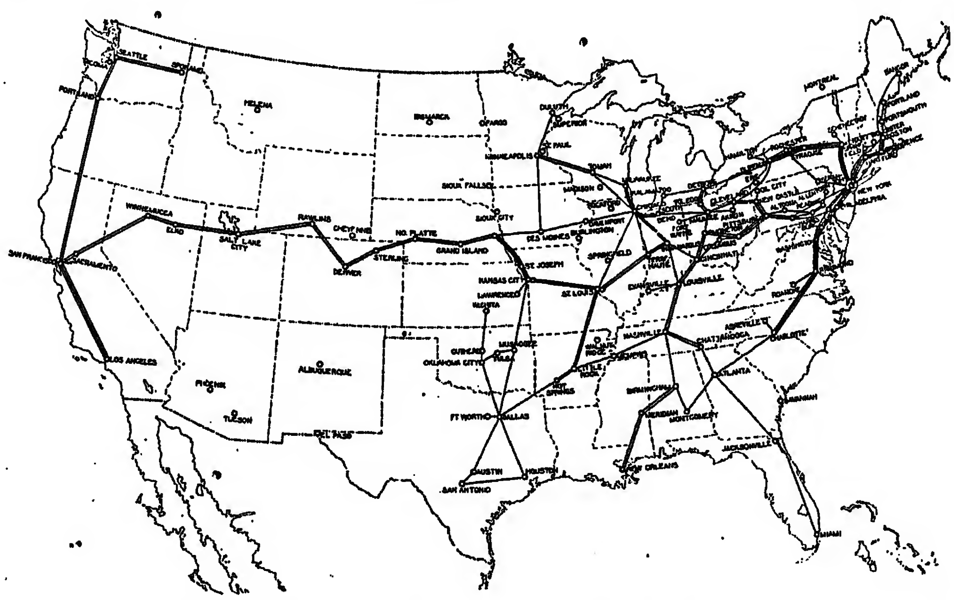

Fig. 1—Bell Sysetm Program Networks in the United States on March 15, 1929

Network	No. of stations	Length in miles
Red — NBC	44	10,800
Blue — NBC	11	3,500
Purple — CBC	42	7,500
Green — ABC	3	1,900
Pink* — ABC	5	1,700
Orange — NBC	5	1,700
White — PPA	21	3,800
Brown — DL	3	450
	134	31,350

The general transmission requirements of circuits for the satisfactory handling of program material are not greatly different from those for good telephone connections. The nature of the program material is usually such, however, that the specific requirements for a network of program circuits are much more exacting than for the usual types of message circuits.

These differences lie in the fact that for satisfactory transmission of speech from the message traffic standpoint the primary requisite is that the message shall be readily recognizable and intelligible with naturalness of tones as an important but secondary consideration; whereas the satisfactory transmission of programs for broadcasting purposes requires faithfulness of reproduction of speech, music and incidental details with intelligibility and naturalness of tone of about equal importance. In order to achieve these effects it is necessary to transmit with reasonable uniformity a wider range of frequencies and volumes than is ordinarily required for message traffic.

For example, if properly utilized a frequency band 2500 cycles in width will provide facilities for the transmission and ready interchange of ideas through the agency of easily understandable speech, whereas for program transmission with the present type of microphones, amplifiers, and loud speakers, a frequency band of between 4000 and 5000 cycles in width is usually

required. Most program circuits at the present time transmit frequencies above about 100 cycles and below about 5000 cycles. The normal range of volumes in programs is usually much larger than can be successfully handled by the present type of radio broadcast transmitters and receivers with the result that at the pickup point the amplification is adjusted from time to time to reduce the variations in volume. This compression is such that for average broadcast material the momentary volume peaks vary over a range of 20 to 30 decibels. The program transmission circuits are arranged to transmit satisfactory volume ranges of this order of magnitude. Since much of the character of large symphony orchestras is contributed by variations in volume, it would undoubtedly add greatly to the pleasure afforded the radio listener to reproduce these variations even more faithfully. It is to be expected, therefore, that within the next few years improvements in the broadcasting technique will be considered from various points of view and the network circuits will be called upon to keep pace with such developments.

with means of rapid intercommunication. To increase the effectiveness of this organization the country has been divided into areas with one of the wire centers listed above designated as the control office for the contiguous area. Telegraph wires are provided connecting each of the repeater offices within a given area with the area control point and the area control offices are in turn connected with New York. By the use of these telegraph wires the reports covering the condition of the circuits and instructions regarding measurements and adjustments required in setting up or rearranging the program circuits are handled. Due to the method used in connecting the branches to the trunk circuits, the various area control offices are able to carry on their work practically independently of the other offices.

To facilitate further the testing and maintenance of the network, the circuits within an area are further subdivided into sections usually about 500 mi. in length. Certain offices are selected and designated as control points for these sections which are known as program circuit units and are established, tested and maintained as independent units. The units are designated by the

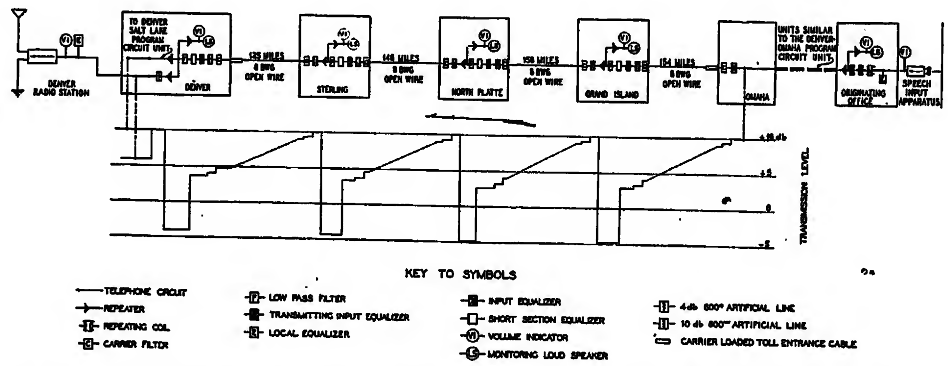

FIG. 2—SCHEMATIC LAYOUT AND TRANSMISSION LEVEL DIAGRAM OF DENVER-OMAHA PROGRAM CIRCUIT UNIT ARRANGED FOR TRANSMISSION FROM OMAHA TO DENVER

The wire networks are arranged for the transmission in only one direction in the same manner as the broadcasting stations. This removes the problem of echoes and possible singing which is introduced where two-way transmission is required. It also permits a more simple treatment of the many connections between circuits involved in supplying programs to a large number of points. The networks are set up with main radial circuits over trunk routes from which branches feeding the various stations are taken off. At these branch points the connection is accomplished with the aid of a one-way amplifier arranged to prevent any reaction on the trunk circuit by conditions on the branch circuit.

New York City is the originating point of the red, blue, purple, and white networks and from it the largest number of wire networks radiates. Atlanta, Cincinnati, Kansas City, Chicago, St. Louis, and San Francisco are also large network centers. The work of properly setting up the veritable web of circuits radiating from and interconnecting these points and properly safeguarding the service, requires the constant attention of a large group of men strategically located and provided

names of the two terminal offices and those between the same two points are numbered successively. Complete networks are established by connecting the necessary number of units together. Any two program circuit units over the same route are so designed as to be interchangeable and a spare unit established for emergency or special use may be used to protect the service on several networks.

To illustrate the factors entering into the determination of the proper set up of a circuit unit, the layout of the No. 1 Denver-Omaha program transmission circuit unit which is a typical one, as well as the transmission levels at the various repeater offices, when arranged for transmission Omaha to Denver, is shown in schematic form in Fig. 2. It may be seen from this chart that the unit is so set up that the gain at each amplifier point just equals the loss in the preceding sections. This results in a uniform level at the output of each amplifier and permits the transmission of the program at a higher average volume level without overloading the amplifiers or introducing interference into adjacent circuits. At each amplifier point there is, in addition

to the amplifier transmitting towards the next station, one which is used for monitoring the circuits and making various service observations. An instrument known as a volume indicator is normally connected to this amplifier and is used to check up on the volume of the transmitted program. It is also used sometimes to obtain a quick check of the strength of tones applied for measuring purposes although there is provided for

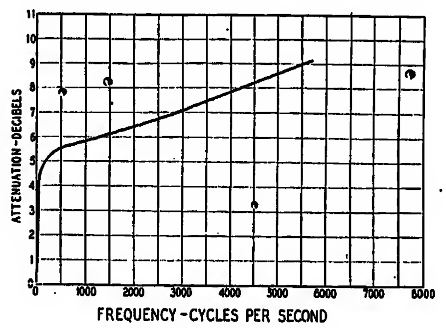

Fig. 3—Line Attenuation of Typical Repeater Section of a Program Transmission Circuit

this purpose special precision transmission measuring apparatus.

The line wires in this case are No. 8 B. w. g. copper, and are not loaded, which is the type generally used for program transmission. The incidental cables for entrance into cities are either No. 10 or No. 13 B. & S. gage and are loaded to have approximately the same characteristic impedance as the line wires; namely, 600 ohms. The cut-off frequency of this cable loading

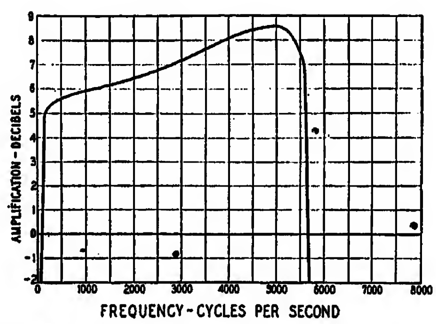

Fig. 4—Over-All Amplification of a Typical Repeater Office on a Program Transmission Circuit

is sufficiently high to permit the operation of the carrier current telephone systems which are connected to these wires. The transmission loss at various frequencies of a typical section of line wires with incidental cables is shown in Fig. 3. The over-all gain at various frequencies introduced at typical repeater points is shown in Fig. 4. It may be seen that within the band which at the present stage of the art the circuits are designed to transmit, the gain is substantially complementary to the loss so that the resultant net loss in each repeater section for the frequencies within this band is practically uniform. The gain of the repeaters at the higher and lower frequencies relative to 1000 cycles is adjustable so that it may be made to conform to the varying conditions likely to be encountered.

In addition to the constant watch which is maintained through the length of the circuit, and particularly at all points where broadcasting stations are connected to the circuits during the transmission of programs, frequent tests are required in order to keep the circuits in shape and prepare them for the periods of use. At the present time complete measurements are made on each program circuit at least once each day, and periodic test of a less comprehensive nature are made at frequent intervals throughout the day. On the complete over-all tests, a testing tone of the required strength and having a frequency of 1000 cycles per sec. is applied at the originating point of the section of network under test. At each amplifier point in succession beginning with the originating point the level of the testing current is measured and reported back to the control office. Such changes as are necessary to bring the level to the required valued are made and when all points have been covered the frequency of the testing tone is changed and

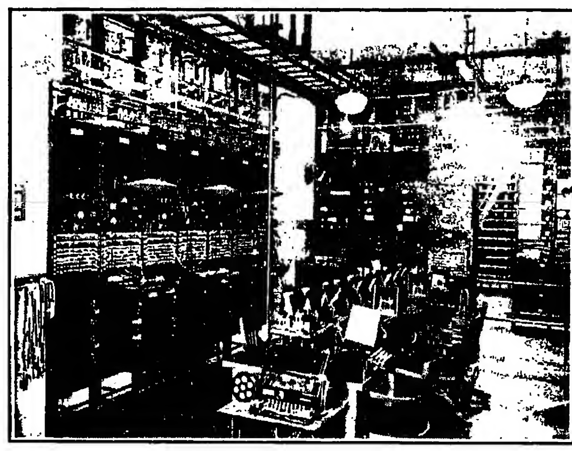

Fig. 5—Part of Equipment at New York for Program Transmission

the procedure repeated. In general, measurements are made at only about four or five frequencies covering the band which it is desired to transmit on the daily tests although in some cases it may prove desirable to measure at as many as forty different frequencies. After completing the adjustments at all necessary frequencies the testing tone is removed and the circuit is observed for any noise, crosstalk or other possible sources of trouble. A test program is then sent over the circuits and reports as to quality are made. To provide for making this last test, the more important control offices are equipped with a high-quality phonograph pickup as well as microphones for talking tests.

Another condition which requires careful coordination on the part of the repeater and control offices is the practise of splitting a network at a specified time to provide for the transmission of one program to a certain group of the network radio stations while the remainder receive programs from a different source. These re-

arrangements may involve the creation of a new point as the temporary originating center, or switching a branch of a network feeding one or more stations from one network to another. Program orders are obtained daily from the broadcasting companies to cover the network set up required for each day's program and these orders are transmitted from New York to the area control office using telephone typewriters. The switches necessary for these rearrangements are then made under the directions of the area control offices.

In the installation of the equipment at repeater stations and distributing centers, care is taken to arrange the circuits so as to provide as great freedom from interruption as practicable and permit the quick rearrangement of circuits which may become necessary during emergencies. The repeaters and associated equipment are grouped together with the telegraph wire terminations and this unit is usually located in a separate room. An example of a part of the equipment arrangements at New York which is typical of the larger wire centers, is shown in Fig. 5.

The foregoing discussion has considered program transmission networks as they are today. At this time any attempt to predict the future course of development would probably require rather extensive recasting at some subsequent time. It seems fairly certain, however, that there will be continual improvements in the general broadcasting art and this factor is kept constantly in mind in the design of telephone circuits for program transmission in the future.

Abridgment of

Lightning Studies of Transformers by the Cathode Ray Oscillograph

BY F. F. BRAND[1] Member, A. I. E. E. and K. K. PALUEFF[1] Associate, A. I. E. E.

Synopsis.—Study of transformers has been under way for some time to coordinate the strength of transformers and transmission-line insulation under lightning conditions. This study has taken two forms; first, the transient dielectric strength of the line end of the winding and second, the distribution of transient voltages and therefore the stress caused by them throughout the winding.

Theoretical studies and spark-gap tests of transient voltage distribution in transformer windings have been previously published by the Institute. Since then an extensive study of transient voltage phenomena has been made by the cathode ray oscillograph on power transformers connected to a short transmission line and subjected to artificial lightning waves sent along the line.

The effects of the transmission line, concentrated inductance, and transformer entrance bushings on traveling waves were studied, as well as the effect of traveling waves of various service conditions in producting internal oscillations in ordinary transformers:

The non-resonating transformer was studied under similar conditions.

A striking agreement between the oscillographic records and theoretical conclusions previously published was found, sufficient to establish beyond any doubt the following conclusions:

1. Very high-voltage oscillations occur throughout the entire winding of even a grounded neutral transformer.

2. Points of the winding near the grounded neutral may rise to 95 per cent of the crest voltage of a very short traveling wave (three microseconds long).

3. Entrance bushings have a negligible effect on the shape of the incoming traveling wave.

4. In case of sudden voltage changes, concentrated inductance in series with the transformer, unless by-passed by a suitable device, causes rise of voltage across the transformer terminals as well as internally in the windings.

5. Arc-over of line insulators by a traveling wave produces severe oscillations in a transformer the amplitudes of which are roughly proportional to the arc-over voltage of the line insulators.

6. Grading the insulation between high voltage and low voltage and ground in ordinary transformers with grounded neutral is a dangerous practise when the transformers are subject to lightning.

7. All the above conclusions apply to concentric winding core type as well as interleaved and shell type transformers. From theoretical studies the non-resonating type of transformer has been developed and its action checked by tests. This type of transformer eliminates voltage oscillation within the winding and therefore local concentration of transient voltage.

An Appendix entitled Present Status of the Cathode Ray Oscillograph on the Measurements of Transients, by H. L. Rorden and J. C. Dowell, both of the General Electric Company, Pittsfield, Mass. is included in the complete paper.

Introduction

Part I

Transformers are, in general, reliable pieces of apparatus; in fact, their reliability is probably higher than that of any other electrical apparatus, but a small percentage of failures does take place and the majority of these is probably due to lightning.

The effect on transformers of high-frequency oscillations and steep-front waves are to some extent similar, and a discussion of the effects of lightning in a measure covers the effects of other high-voltage transients.

Part II

Lightning Failures of Transformers

Transformer failures sometimes occur directly through the major insulation from high-voltage winding to low voltage or ground, either near the terminal or in the main body of the winding.

Failures are more liable to occur between turns or

1. Both of the General Electric Company, Pittsfield, Mass. Appendix.

Presented at the Regional Meeting of the South West District No. 7 of the A. I. E. E., Dallas, Texas, May 7-9, 1929. Complete copies upon request.

coils of the same winding or in auxiliary parts connected to the winding, such as taps, tap terminal boards, or ratio adjusters.

Failures which occur through the major insulation near the line terminal are due to excessive voltage applied to the transformer.

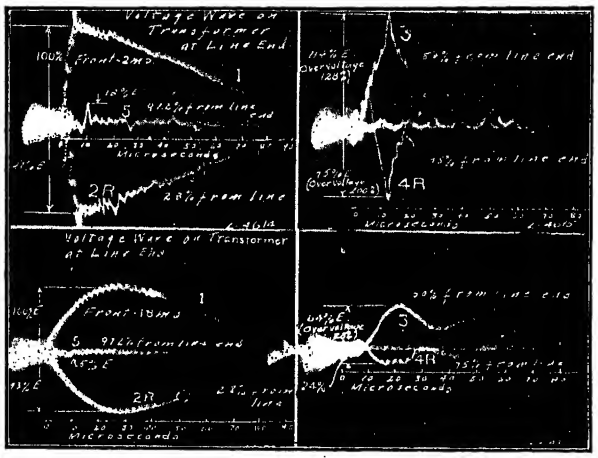

FIG. 6—EFFECT OF FRONT OF TRAVELING WAVE. 6600-KV-A. TRANSFORMER

Top

"Exceedingly steep front" and long tail
1. Voltage across transformer
2, 3, 4 and 5 are voltages to ground at points 97.2, 50, 25, 2.8 per cent away from ground terminal with crest values of 97, 114, 75, and 18 per cent of applied voltage, respectively

Bottom

"Steep front" and long tail
1. Voltage across transformer
2, 3, 4, and 5 are voltages to ground at 97.2, 50, 25 and 2.8 per cent away from ground end with crest values of 93, 64, 24 and 5 per cent of applied voltage

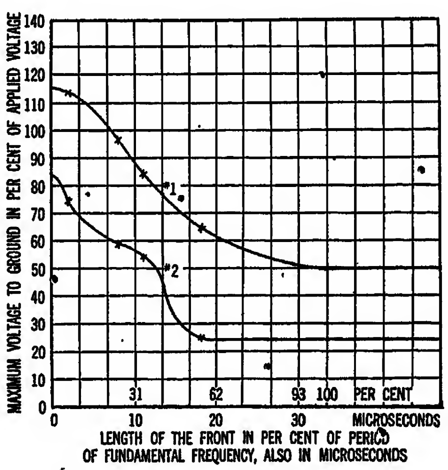

FIG. 7—EFFECT OF STEEPNESS OF FRONT OF THE TRAVELING WAVE ON VOLTAGE TO GROUND (TEST)

1. Point of winding 50 per cent away from ground terminal
2. Point of winding 25 per cent away from the ground terminal

Failures occurring internally in the winding or auxiliary parts are due not only to the voltage to which the transformer is subjected but to the nature of the surge and its effect in the transformer.

It is obvious that irrespective of what might be called the internal effect of the surge on the transformer, some limit must be set to the voltage which may be applied to the transformer. If this is not done failure will occur in any transformer.

Part III

LIMITS OF VOLTAGE ON TRANSFORMER INSULATION

The voltage required to cause breakdown by lightning is higher the greater the energy required for a particular

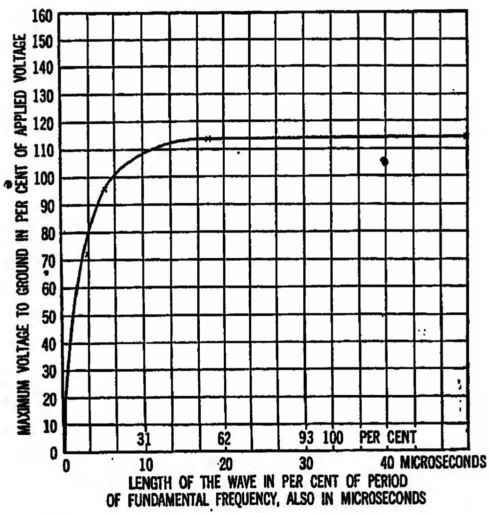

FIG. 8—EFFECT OF THE LENGTH OF TRAVELING WAVE ON VOLTAGE TO GROUND OF POINT OF WINDING 50 PER CENT AWAY FROM GROUND TERMINAL (TEST)

kind of insulation. It is fortunate that the oil and most solid insulations require greater energy to cause breakdown than air, and therefore higher lightning voltage for the same 60-cycle strength.

To determine the lightning breakdown voltage of

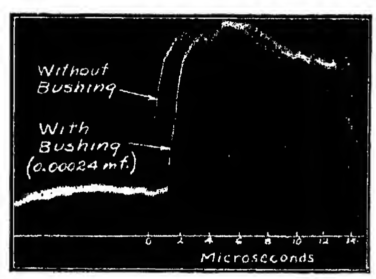

FIG. 10—EFFECT OF BUSHING ON SHAPE OF TRAVELING WAVE

(To avoid confusion two waves were displaced along time coordinate as shown)

even the simplest insulation structure, requires a knowledge of the wave form of the applied voltage.

When lightning sparkover of insulators is referred to it is usually based on data published by F. W. Peek, on the insulator sparkover under artificial lightning produced in the Pittsfield Laboratory.

Based on this wave form, a string of suspension insulators requires a voltage of approximately 1.8 to 2.0 times the 60-cycle dry sparkover voltage to cause

lightning sparkover. Sparkovers caused by natural lightning have given the same range.

Corrugated or petticoated bushings such as are used for outdoor service require a lightning voltage from 2.0 to 2.5 times the 60-cycle dry sparkover voltage depending upon design.

Oil and other solid fibrous insulation such as that

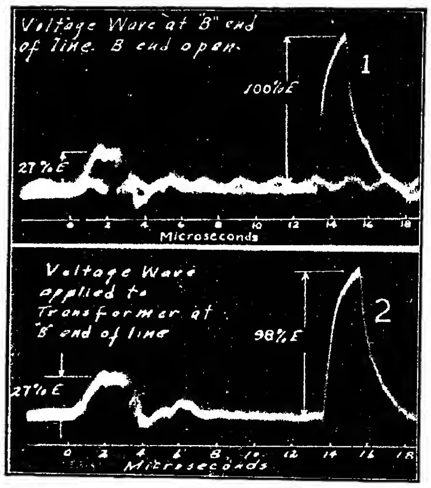

Fig. 11—Effect of Transformer on Incoming Traveling Wave

1. Wave at the end of transmission line with transformer disconnected
2. Wave at the end of transmission line with transformer connected (voltage across transformer)

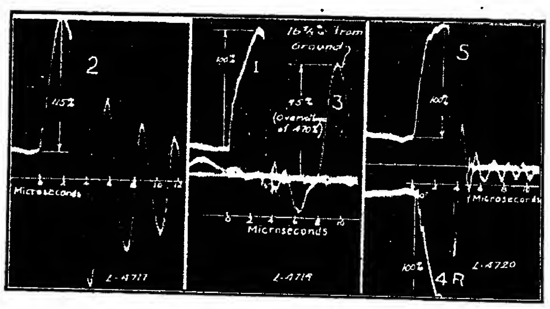

Fig. 12—Effect of Series Inductance in Case of Traveling Wave of Very Steep Front and Tail

A Inductance of 1.0 μ h.
1. Voltage applied across transformer and inductance in series
2. Voltage across transformer. Crest value 115 per cent of the applied wave (Curve No. 1). Frequency of oscillation 333 kilocycles
3. Voltage to ground at point of winding 17 per cent away from the grounded end. Crest value 95 per cent of applied voltage
Note, front of the wave No. 2 is steeper than No. 1. Approximate effective capacitance of the transformer winding 0.00206 μ f.
B. Inductance of 0.24 μ h.
4*R*. Voltage applied across inductance and transformer
5. Voltage across transformer. Crest value 100 per cent of the applied voltage. Frequency 710 kilocycles. Note, front of the wave No. 5 the same as No. 4*R*. Approximate effective capacitance of the transformer winding 0.0019 μ f.

used in oil-immersed transformers require from 2.8 to 3.5 times the lightning voltage compared to 60-cycle one-minute breakdown voltage. These ratios are crest-to-crest value.

This ratio does not hold good for the ratio of standard factory test voltage to 60 cycles to the breakdown value under lightning of completed transformers due to two causes:

1. The completed transformer has a margin of safety over the factory test. This margin varies with voltage rating, being usually higher in the lower rated voltage apparatus.

2. The ratio holds for a simple insulation test piece and does not take into account the essential difference between the voltage distribution along a winding at low (that of Standard Insulation Test) and high (that of surges met in service) frequencies.

Parts IV and V

Parts IV and V of the original paper deal in a non-mathematical way with the laws governing the behavior of a transformer under high-frequency excitation

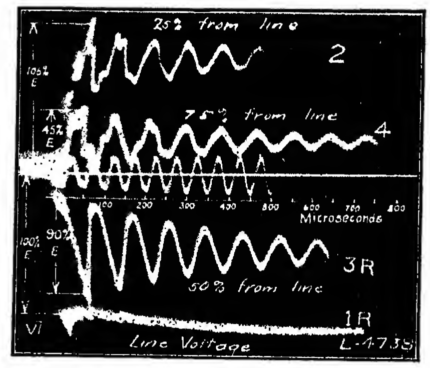

Fig. 13—Effect of Transformer Losses on Damping of Transient Voltages

Oscillations of shell type transformer caused by long traveling wave of eight microseconds front
1*R*. Applied voltage
2, 3*R*, 4. Voltages at points 75 per cent, 50, and 25 per cent away from ground end, with crest values of 106 per cent, 90 and 45 per cent

Part VI

Tests by Cathode Ray Oscillograph

In order to check previous theoretical studies of the behavior of transformers under lightning, and tests made by spark-gap measurements, a series of tests by an artificial lightning generator in connection with a short transmission line has been made by the cathode ray oscillograph.

Where convenient several oscillograms were recorded on the same film. In such cases some waves were taken above the zero line, then the polarity of the oscillograph was reversed and the remainder of the waves recorded downward below the zero line. The waves obtained with reversed polarity are marked *R*. The crest value of the wave at the transformer end of the line (see Fig. 20) was considered as unity and crest values of all other waves expressed in per cent of this value.

The voltage of any given point of the winding to ground is considered "normal" if it is the same percentage of the crest of the applied wave as it is under normal operating frequency excitation. Excess over

this value is called "overvoltage" and is expressed in per cent of the "normal" voltage.

The tests were made on an overhead transmission line over two miles long having a surge impedance of

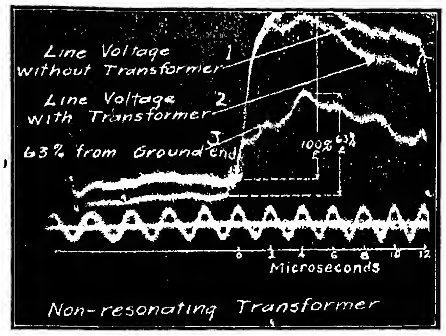

FIG. 14—NON-RESONATING TRANSFORMER

1. Voltage wave at the end of transmission line with transformer disconnected
2. Voltage wave at the end of the transmission line with transformer connected (voltage across transformer)
3. Voltage at 63 per cent point. Crest value 63 per cent of applied voltage

Note No. 3 a practical duplicate of the shape of No. 2 in spite of the fact that the transformer was out of oil and electrostatic unbalance was created thereby

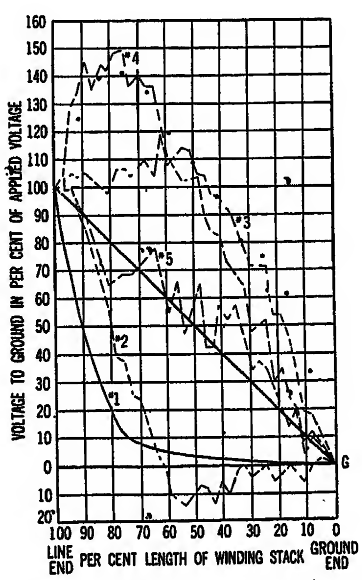

FIG. 15—SIMULTANEOUS VOLTAGE TO GROUND PRODUCED BY A SINGLE TRAVELING WAVE (TEST)

1. At the instant of impact ("initial" voltage distribution)
2, 3, 4, and 5.—3, 14, 18 and 24 microseconds later respectively

Dots show results of calculation (same as curve 3, Fig. 2) of maximum voltage to ground

350 ohms. The following apparatus was used at various times in the tests:

6600-kv-a. 110-kv. circular coil type transformer

1000-kv-a. 44-kv. shell type transformer

Air-core inductances of 1.0 amd 0.24 millihenry

110-kv. solid insulation transformer bushing having a capacitance of 0.00024 microfarads.

Various protective spark-gaps with and without resistance in series.

To date more than 600 records have been obtained representing a very wide range of service conditions affecting the voltage transients.

The agreement between theoretical predictions[4] and experimental results is striking.

In the original paper, general laws are stated covering the effect on transformer oscillations of the front, length, and tail of a traveling wave; also of entrance bushing and the concentrated inductance (like reactors, current transformers, etc.).

EFFECT OF INDUCTANCE IN SERIES WITH TRANSFORMER

Inductances, such as current-limiting reactor or current transformer, if not bridged by a proper by-pass device, enter into oscillation with the effective capacity of a transformer to which they are connected where struck by traveling wave.

Such oscillations may create very severe overvoltage

FIG. 18—220 KV.- AND 37,000-KV-A. (EQUIVALENT CAPACITY) THREE WINDING NON-RESONATING TRANSFORMER

500-kv. insulation test

inside of the transformer and cause voltage across the transformer in excess of the crest value of the incoming wave. These oscillations also take place in case of arcing grounds or switching.

Inductances of much smaller values have negligible effect on incoming wave but also enter into oscillation, overstressing the line end of the transformer winding,

4. See *Effect of Transient Voltage on Power Transformer Design*, by K. K. Palueff, A. I. E. E. Quarterly TRANS., Vol. 48, April, 1929.

Part VIII

The Non-Resonating Transformer

The reason that the voltage distribution in a transformer under surges is not uniform and that oscillations take place may be briefly stated to be:

Because the electrostatic charging current of the ordinary transformer has to flow through the winding.

If the electrostatic charging current is directly supplied to the various parts of the winding in the proper proportion, then unequal voltage distribution and oscillations will be eliminated.

This principle is the basis of design of the non-resonating type of transformer. At the present time in commercial designs, it is limited to transformers operating with neutral grounded directly or through a moderate impedance.

Thus by properly proportioning the electrostatic characteristic of the transformer, the voltage distribution throughout the winding is made a straight line falling from line terminal to ground, irrespective of the frequency or wave shape of the applied voltage.

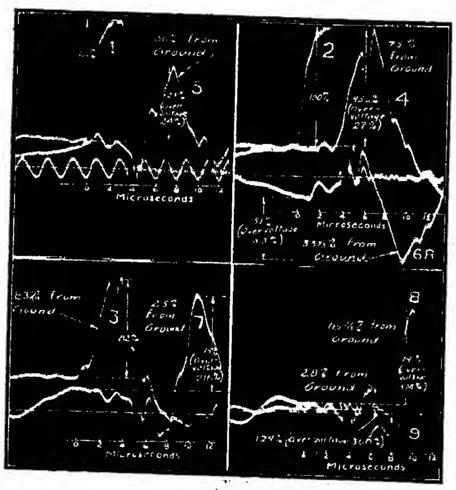

Fig. 21—Oscillations Along Winding Due to Short Traveling Wave of "Exceedingly Steep" Tail, Produced by Sparkover of Line Insulator

1. The traveling wave applied to transformer
2. Point 97.2% from ground end—Crest 100% of applied voltage
3. Point 83.3% from ground end—Crest 82% of applied voltage
4. Point 75% from ground end—Crest 96% of applied voltage
5. Point 50% from ground end—Crest 62% of applied voltage
6. Point 33% from ground end—Crest 51% of applied voltage
7. Point 25% from ground end—Crest 79% of applied voltage
8. Point 16% from ground end—Crest 79% of applied voltage
9. Point 2.8% from ground end—Crest 13% of applied voltage

In practise, the non-resonating winding is uniform and concentric with the low-voltage winding. The coils are relatively narrow. Standard circular coils are used, connected together successively at the inside and outside turns, so that cross-connections from inside to outside of coils are avoided.

The mechanical design of the transformer follows long established practise, lending itself readily to assembly and handling, and embodies the usual desirable characteristics such as free oil circulation and ability to withstand short circuit stresses.

In the new transformer, voltage stresses between turns and coils under lightning conditions are reduced in the order of from 10 to 1 to 100 to 1. The over-voltage to ground caused by oscillations being eliminated, results in decreasing the stress to ground sometimes as much as 6 to 1. The elimination of local excess voltage between turns and coils reduces the probability of arc-over of tap terminal boards, ratio adjusters, etc.

The proportion of voltage stress in all parts of the winding under all conditions of voltage and frequency remains the same as that during the factory insulation test, which therefore becomes a real measure of the ability of the transformer to resist lightning. This never could be tested correctly before.

In such a transformer, since all voltage stresses are under complete control and are made uniform throughout the winding for all frequencies, the reliability will naturally be much greater than in ordinary transformers.

FOUNDRY COSTS REDUCED BY LIFTING MAGNETS

Lifting magnets may be advantageously used in gray iron foundries for many material-handling jobs. Some of the direct possibilities were pointed out by Albert Walton, consulting engineer, of Philadelphia, at the recent convention of the American Foundrymen's Association. As mentioned by Mr. Walton, magnets may be used for unloading pig iron and scrap from railroad cars, for stocking this material in the yard and for handling it to cupola charging boxes and buckets. In direct cupola charging, if the operation is continuous for a number of hours, it is advisable to use two magnets alternately, since one will heat up considerably in continuous use. The change, however, does not have to be made oftener than every one and one-half to two hours. Magnets may be used for the handling of iron slabs on the molding floor and also for lifting iron or steel copes, picking up and transferring castings to the cleaning room or to suitable trucks and for going over molding floors after the castings are removed and picking up gates, risers, nails and other pieces of iron and steel. By the use of magnets on the work described a reduction in labor cost can be made down to one-tenth of what it would be without mechanical appliances. A single magnet installation will replace ten or twelve men on this class of work and it will do the work more effectively and quicker.—*Electrical World.*

Abridgment of

Meeting Long Distance Telephone Problems

BY H. R. FRITZ[1] and H. P. LAWTHER, Jr.[2]

Associate, A. I. E. E. Associate, A. I. E. E.

Synopsis.—There have been presented before the Institute numerous papers describing various technical and apparatus developments of value in providing long distance telephone service. Several papers have also appeared covering specific transmission or operating problems, or dealing with the advance planning of the telephone plant. Feeling that it might be of interest, particularly to the young engineering graduates, the writers have prepared this over-all sketch of the general problem of actually providing, year by year, the extensions and additions to a comprehensive network of communication channels necessary to keep pace with a growing public demand for long distance service. Since the writers are most familiar with the area served by the Southwestern Bell Telephone Company, the discussion will be restricted to that territory.

* * * * *

THE Southwestern Bell Telephone Company operates in the states of Missouri, Arkansas, Kansas, Oklahoma, Texas, and a small section of Illinois which is socially and economically associated with greater St. Louis. This is primarily an agricultural region but there are several large manufacturing centers and extensive areas devoted to oil and mineral production. The great difference in climatic and soil conditions which exist over such a wide territory naturally brings about a diversity of agricultural interests. Local seasonal peak demands for long distance service occur at the times when crops must be marketed and moved.

Because of its fortuitous occurrence and the sudden and imperative demand for long distance service attending its discovery, oil creates the most difficult problems. Through some preverse trick of fate, the deposits have been found uniformly in areas otherwise of no great economic importance and having either no, or very little, telephone development.

Contributing more than any other item to the problem of keeping abreast of the demand for long distance service is the fact that the Southwest is still immature in the social and economic sense, and is growing lustily, and at a rate which rarely fails to exceed the most optimistic forecasts.

Beside these purely local peculiarities which contribute to the problem, there is the generally increasing demand for long distance service on the part of the public. Based fundamentally on the increase of wealth and prosperity, traffic growth has been accelerated by better service and reduced rates. New and improved apparatus and methods become available from time to time—and not the least of the tasks of the field engineer is the more or less continuous modernization of an existing plant.

With this picture of the factors affecting the demand for service, it will be interesting to note the extent and complexity of the long distance network required. The map, Fig. 1, shows the principal towns and cities of the Southwestern area, and the single lines connecting them represent circuit routes. There may, of course, be a large number of communication channels on each route. Not all of the cities and towns, and not all of the circuit routes shown are Bell owned and operated. Long distance service must be universal and considered independently of who owns and operates the plant.

In addition to the network shown on Fig. 1 there is

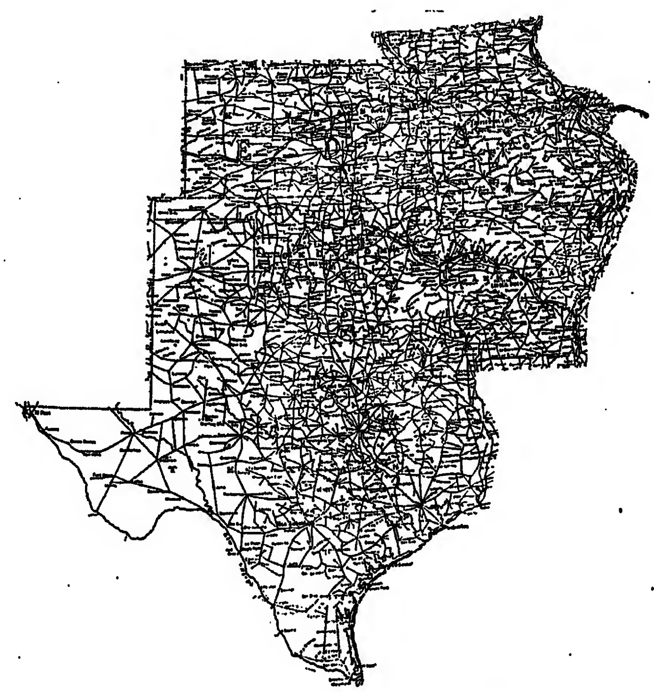

FIG. 1—LONG DISTANCE LINES

the long distance telephone plant of the Long Lines Department of the American Telephone and Telegraph Company. This department is organized to supply the extreme long distance facilities necessary between the several Associate Company areas in order that universal service may be realized. This paper does not include consideration of the Long Lines Department's plant or its problem.

1. Southwestern Bell Telephone Co., St. Louis, Missouri.
2. Southwestern Bell Telephone Co., Dallas, Texas.

Presented at the Regional Meeting of the South West District No. 7 of the A. I. E. E., Dallas, Texas, May 7-9, 1929. Complete copies upon request

The fundamental requirements of any link of a system of long distance facilities is that it must talk satisfactorily. It must be capable of transmitting speech easily and without undue effort on the part of the users. To accomplish this, there must be:

1. A sufficient volume so that speech may be received with adequate loudness.

2. Freedom from distortion so that speech will be satisfactorily intelligible.

3. Freedom from extraneous interference.

Each circuit, together with all of its associated equipment, must be designed to comply with these basic requirements. Not only must it furnish adequate transmission as an individual unit, but it must also perform satisfactorily as a link of the whole system.

In addition to regular long distance telephone communication, it is necessary that certain special services be furnished. The radio public demands the chain broadcasting of programs and the frequent picking up of programs at points remote from the radio transmitting stations. This requires the setting up of very reliable and extremely high quality telephone channels. Extraordinary freedom from distortion and noise is necessary, since even with the perfection of modern amplifying and loudspeaking devices the quality of a radio program must exceed that of a simple transmittal of intelligible speech in order that it may prove enjoyable. The simultaneous operation of telegraph over wire facilities primarily placed for telephone service has long been practised. Telegraph facilities, then, are a by-product of the telephone business, and economy dictates that these be made use of as fully as practicable. Picture transmission is still before the public for trial. Should a widespread demand develop, it will be necessary to set up a network of communication channels surpassing all previous standards.

There are three types of facilities available for providing long distance circuits. These are open-wire, carrier-current systems (superposed on open wire), and cables. The first two are closely interrelated and are of service in the early and intermediate stages of development, while the last is the final goal of progress at the present stage of the art.

Open-wire was the first and is still the main reliance for providing circuits in this country. In a large area of low population density, such as that of the Southwest, open-wire must constitute the bulk of the plant for a number of years to come. Three sizes of copper wire now find general application. These are designated 104, 128, and 165, the figures indicating the respective diameters in thousandths of an inch. Improved transmission through the use of copper wire larger than 165 is unduly expensive, while sizes smaller than 104 do not possess the requisite mechanical strength for resisting the stresses of storms. Copper open-wire circuits possess electrical characteristics so ideal as to endear them to the hearts of transmission engineers. With the aid of suitably spaced telephone repeaters they may be extended to practically any distance. Iron wire has lost its place in a plant designed for universal service. Having, when new, a transmission efficiency only one-fourth that of the same size of copper, due to corrosion, iron wire becomes progressively worse from the day of its installation. This instability renders it wholly unsuited to the application of telephone repeater improvement and thus so seriously restricts its flexibility that it has been determined to eliminate iron wire completely from the long distance plant. The application of the principle of loading to open-wire facilities has been rendered totally obsolete on account of the better performance and greater flexibility of non-loaded open-wire with repeaters.

It is generally impossible to continue in open-wire up to the central office in a city. In such instances, it is the practise to terminate the open-wire out beyond the city congestion and to bring the circuits into the office over specially designed entrance cables. These entrance cables must often be of considerable length and add materially to the transmission losses. Through the application of the proper systems of loading, the cable circuits may be made to match the impedances of the open wire circuits, and thus preserve the full possibilities of telephone repeater operation.

For several years now carrier-current systems have been available by means of which additional telephone channels may be derived from existing and suitable open-wire facilities. For distances beyond certain minimum figures, these carrier systems yield telephone channels more economically than possible through the placing of additional open-wire. The outstanding usefulness of carrier systems, however, lies in the increased capacity they confer upon an existing open-wire structure. It is thus possible to defer heavy expenditures for major relief.

There are two types of carrier telephone systems in general use. One provides three additional telephone circuits besides the one furnished by the pair of wires over which it must operate. Under favorable conditions it is economical as compared with stringing of wire for distances of as short as 150 miles, and by the use of carrier repeaters spaced at regular intervals it may be extended to any distance. The other provides one additional talking circuit and finds its application with distances between 50 and 200 miles.

At the higher frequencies of the carrier systems the attenuation offered by the open-wire circuits is greatly increased over that experienced at voice frequencies. When it is remembered that cross-talk effects increase almost directly with frequency and are a function of the energy level differences between the disturbing and the disturbed circuits it will be realized that the application of carrier systems to an open-wire lead may present serious difficulties. Transposition arrangements quite satisfactory for voice frequencies are totally inadequate for the carrier range. Special systems of transpositions must therefore be employed which, in addition to

making use of extremely elaborate patterns, must be spaced with great precision.

The necessary entrance cables which complicate voice-frequency transmission problems constitute a proportionately more serious problem at carrier frequencies. To reduce attenuation and to limit reflection effects, the cable conductors must be suitably loaded for carrier operation. For the frequency range employed by the three channel system, loading coils must be placed at 930-ft. spacing. In the case of underground construction, it is rarely possible to realize this ideal spacing on account of manhole locations. It then becomes necessary to place the loading coils at something less than the theoretical spacing, and to build out the short sections to the required capacity by means of special stub cable connected in shunt with the loaded conductors. In order to avoid carrier cross-talk in entrance cable it is necessary to maintain a degree of segregation among the conductors assigned to carrier operation.

Despite elaborate preparations in the form of special transposition of the open wire and loading and segregation of entrance cable conductors, it is still not possible to operate carrier systems indiscriminately on any open-wire lead. Serious energy level differences and opposite directions of transmission with the frequency groups must be avoided. All the systems on a lead cannot always be coterminous, for a lead may be hundreds of miles in length, while carrier systems over it will serve various intermediate and overlapping lengths. At any intermediate point it may be desirable to introduce a system terminal with its high output level to operate in parallel with other systems whose energy has been greatly attenuated in transmission from distant terminals. Such differences in level have to be minimized either by separation on the pole head or by the introduction of repeaters to raise the lower energy levels. Junctions with other open-wire lines and the generally complex nature of the open-wire network give rise to situations such that it is practically impossible to realize completely the theoretical carrier possibilities.

Further exploitation of the remaining carrier potentialities on open-wire leads is blocked by the use of phantom circuits which definitely limit the transposition refinements needed to restrict the cross-talk. For important open-wire leads consideration is therefore being given to abandoning phantom circuits on all wires of the first four arms, except the pole pairs. A further simplification of the cross-talk problem can be made by reducing the spacing between the wires constituting a pair from 12 to 8 in. and correspondingly increasing the spacing between pairs from 12 to 20 in.

The nature of the long distance telephone development and the growing requirements of the Southwest have furnished a particularly favorable field for the application of carrier telephone. The distance between many of the more important cities is from 200 to 300 mi., and the three-channel system has been made large use of in spanning these. The single-channel system has found equally widespread application. The use of carrier telephone has grown until the present day finds some 35,000 mi. of telephone channel obtained by this means in the Southwest. The map of Fig. 2 shows the extent of this development, which represents about one-sixth of that of the entire United States.

From the discussion so far it is clear that with any open-wire lead the condition will be reached ultimately when the maximum wire load is in place and the fullest possible use of carrier has been made. It then becomes necessary either to build additional open-wire lines or else have recourse to some other means. Where the circuit growth is sufficiently rapid, economic studies rule in favor of cables in place of building one or more sup-

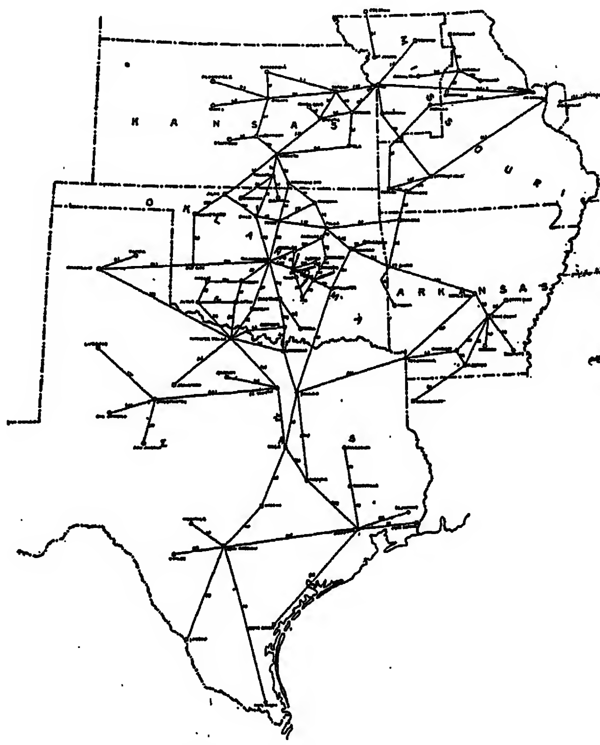

FIG. 2—CARRIER CIRCUITS IN SOUTHWEST

plementary open-wire lines. In addition to proving in from a strict economy standpoint, cables offer many advantages as a medium for long distance circuits. Increased freedom from interruptions due to physical failure of the plant, lower susceptibility to external interference, and more stable operating conditions are some of the benefits accruing. In the territory of the Southwest, the condition is rapidly approaching when cables will be needed between nearly all of the important centers. To meet this situation a cable program has been adopted for the period 1929-1933, which will connect most of these points. This is shown on the map of Fig. 3. Of the cables in the program the sections between Oklahoma City and Tulsa, Oklahoma City and Holdenville, and Dallas and Cisco are under way and will be completed during 1929. As it now stands, the

program provides for a total of approximately 2600 miles of cable for the five years.

The Tulsa-Oklahoma City and the Fort Worth-Cisco sections of the cables mentioned above will represent a unique departure from the previously standard practises of this country. The usual lead-covered cable is to be manufactured and then given a protective coating including several layers of jute and tar and two servings of steel tape armor. A trench is to be dug and the cable simply placed therein and

FIG. 3—TOLL CABLE PROGRAM FOR PERIOD OF 1929-33

covered up. When it is realized that a standard 750-ft. length of this armored cable, together with its reel will weigh about five tons and that the route is to be strictly cross-country, it will be appreciated that some interesting construction difficulties must be met and solved. It is planned to present the story of these installations to the Institute at a later date.

Whether the channels for long distance circuits are derived by means of open-wire carrier systems, or cables, elaborate installations of equipment are required at the circuit terminals and at the intermediate repeater stations. The placing of this equipment and the providing of the necessary building space for housing it constitute major problems. Building additions must be made or even complete new buildings erected, new equipment must be installed and placed in service, and existing working equipment must be relocated to best advantage—all without interrupting the service. Also, irrespective of the means used to derive the communication channels, arrangements must be made at the terminal offices whereby any two circuits may be connected together and a built-up connection thereby established between two terminals not having direct-circuit connection. The problem comes in arranging for such interconnections with the result that built-up connections shall satisfy the same fundamental transmission requirements as are demanded of the individual links. To meet the volume requirement it is essential that a definite gain be inserted whenever two circuits are connected together. The practise of the past has been to provide with repeaters certain of the cord circuits appearing at the switchboard positions which handled switched traffic. The fundamental weakness of this method lay in the fact that the insertion of the proper gain was left in the hands of a very human operator, and there was always the possibility of its being omitted. The latest practise eliminates this element of human fallibility. The switchboard positions are equipped with but one type of cord circuits. When a connection is established between two long distance circuits the proper gain is automatically provided; when a connection is established between a long distance circuit and a local telephone no gain is inserted since none is necessary. The distortion and interference requirements are met for built-up connections simply by causing the individual links to meet sufficiently high standards in these respects so that a chain of four or five in tandem will still yield a satisfactory grade of over-all transmission.

An interesting review of the growth of the various

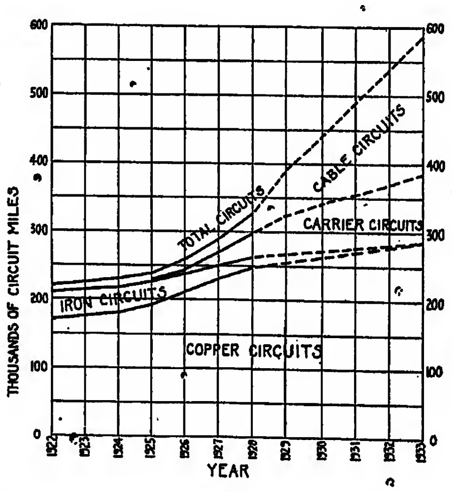

FIG. 4—GROWTH OF LONG DISTANCE CIRCUITS

types of facilities used to derive long distance telephone circuits in the Southwest is shown on the diagram of Fig. 4. The rise and fall of iron wire, the abrupt rise to prominence of carrier systems and cables, and the rapidly mounting total are significant of the present trends.

Abridgment of

Developments in Network Systems and Equipment

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and

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Synopsis.—This paper in its complete form presents in brief review the development of the automatic network system in the seven years since its introduction. It covers the interesting features of design found in the different systems, the changes that have been made in the design of the apparatus as a result of experience, some of the problems that have been faced in the application of the system, and finally the lines along which thought is now being directed in the future development of the system.

THERE has been a great deal written in recent years in regard to the a-c. low-voltage network type of distribution system. The various requirements which caused such a system to be evolved, the fundamental principles of the design and operation of such a system, and the equipment used in it have been described in various technical papers. It is felt, however, that it would be interesting at this time to review the growth of the network system and to observe what developments have occurred in its design and to point out what changes have been made in the apparatus used as a result of the experience gained and in order to meet the requirements of various types of systems.

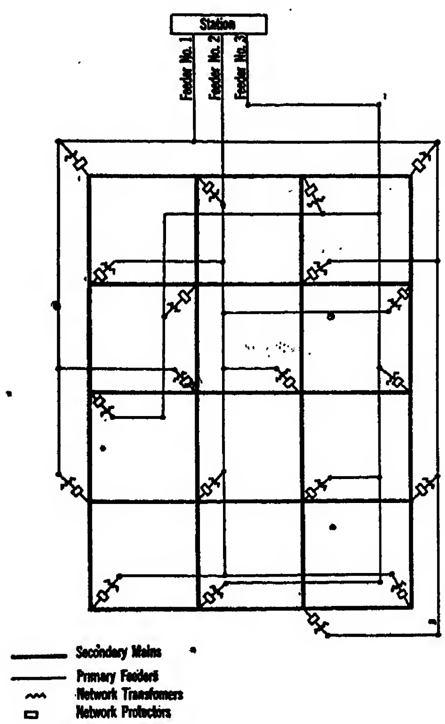

FIG. 1—DIAGRAM OF SMALL AUTOMATIC SECONDARY NETWORK SYSTEM SUPPLIED BY THREE INTERLACED RADIAL FEEDERS

A single-line diagram of an automatic secondary network system is shown in Fig. 1. The United Electric Light & Power Co. installed the first system of this type in the up-town district of New York City in 1922.[3]

In this country, 22 companies now each have a system of this type in operation, six are installing it, five have decided upon it, and it is being given serious consideration in at least 20 other localities. The network has been introduced in four foreign cities,—one in Cuba, one in Mexico, and two in South America,—and is being seriously considered by one other South American and one European city. In all of these systems the fundamental principles of the original design have been retained, but the details of the layout have naturally been adapted to meet local conditions.

NETWORK PROTECTORS

The piece of apparatus that has made the automatic network system possible is the network protector. Although there was no extensive experience on which to base the original design, it is worthy of note that with only minor modifications it has stood the test of service for a period of five years. During this period the protectors on one system were called upon to open or close a total of more than 200,000 times and the number of times that they failed to function properly amounted to less than four-tenths of one per cent. The reports on the operation of the switches on other large network systems show even better results.

About a year and a half ago it was decided to make a complete redesign. A new network protector was brought out which retained all of the operating principles of the original unit but had incorporated in it the features that five years' experience had shown to be desirable. Two views of this type of protector mounted in a subway housing are shown in Figs. 2 and 3.

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Presented at the Regional Meeting of the South West District No. 7 of the A. I. E. E., Dallas, Texas, May 7-9, 1929. Complete copies upon request.

3. *Underground A-C. Network Distribution for Central Station Systems*, A. H. Kehoe, A. I. E. E. TRANS., Vol. XLIII, 1924, p. 844.

Because of the good service it had given in the first type of protector, the circuit breaker type of construction was retained. A rather novel arrangement was adopted, however, by means of which the moving contact is made an integral part of the main copper bus and is simply laminated to give the needed flexibility.

The advantages of a motor-operated closing mechanism over a solenoid type in the reduction of the jarring at the time of closing, the reduction of the current required to perform the operation and the consequent reduction in the size of the device required to break this current has been appreciated for some time. This type of device was not used on the original unit, however, because of the lack of a suitable low-speed motor mechanism including a trip-free feature to permit the protector to open at any time without retardation due to the action of revolving flyballs. Such a mechanism was developed and the motor was adopted as the standard closing device in the new protector.

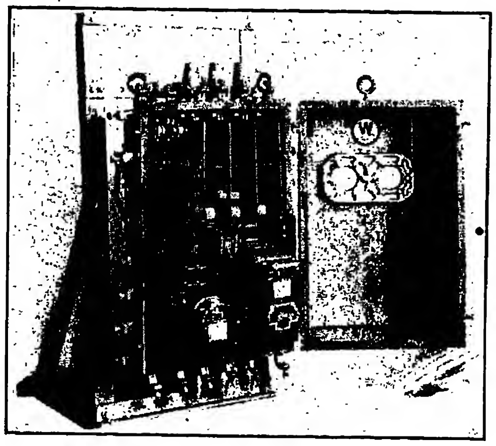

FIG. 2—NETWORK PROTECTOR WITH CONTROL PANEL CLOSED

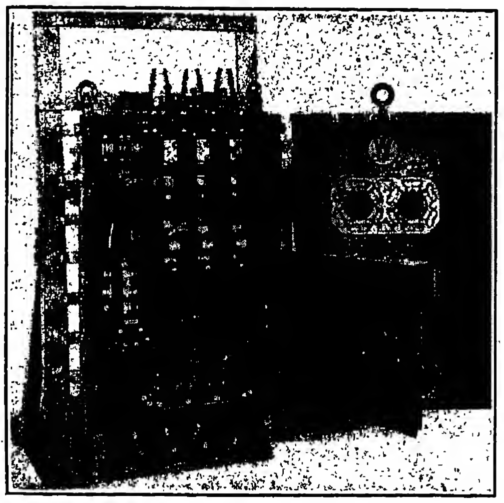

FIG. 3—NETWORK PROTECTOR WITH CONTROL PANEL SWUNG OPEN

The action of the motor is transmitted to the breaker through a system of levers which has been so designed that the breaker is locked closed by the action of a toggle joint being drawn over the center. As a result of this, no latching triggers are in motion while the breaker is closing and the danger of the breaker failing to remain closed in minimized.

The shunt trip device was adopted as the standard in the new protector but only after the design of the entire mechanism was made such that as little as 15 volts impressed across the shunt trip coil will supply the energy required to cause positive operation. It is not likely that a condition will ever present itself where less than 15 volts will be available for tripping.

One of the biggest problems confronting those who designed the first network protector was the development of a type of relay in which could be centered the entire control of the protector. The satisfactory manner in which this design was worked out is shown by operating records which indicate that only about 25 per cent of the very small amount of trouble experienced with the original protectors can be charged against the relays. It is true, however, that the design was rather complicated and in redesigning the foremost purpose was to simplify and at the same time retain and improve the operating characteristics.

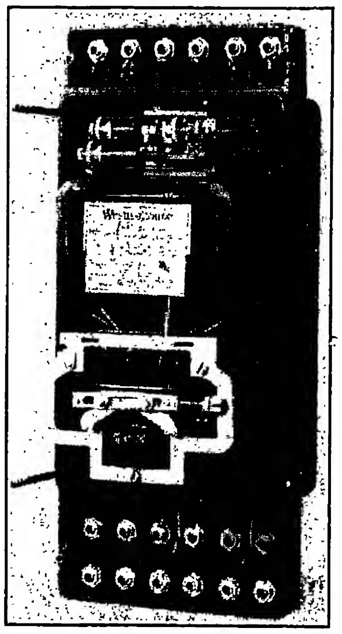

FIG. 4—THREE-PHASE NETWORK RELAY (GLASS COVER AND TERMINAL CHAMBER COVERS REMOVED)

A three-phase relay was developed to take the place of the three single-phase relays that were formerly used. The three-phase relay has decidedly better closing characteristics than the single-phase type and also gives somewhat better performance under certain secondary fault conditions.

The detailed design of the three-phase master relay

represents a decided simplification. It has been possible to design a relay having wattmeter tripping and approximately wattmeter closing characteristics and still eliminate the holding coil, adjustable slide wire resistor, fixed resistor and auxiliary contactor which were required in the first network protector relays. A view of the three-phase relay is shown in Fig. 4.

There are system conditions under which pumping,—that is, periodic opening and closing of the network protector,—might result with a three-phase relay as well as with the three single-phase relays. To prevent

FIG. 6—SEPARATELY MOUNTED GROUNDING AND DISCONNECTING SWITCH

this a single-phase relay known as a phasing relay is supplied along with the three-phase master relay. When acting along with the master relay the phasing relay prevents the protector from closing under any conditions where the current that would flow after closing might cause the protector to reopen again and thereby absolutely prevents pumping action.

The entire design of the new protector has been worked out on the basis of maximum accessibility for maintenance and repairs. Everything is mounted on the front of the panel and the entire protector has been built up on the unit principle.

NETWORK TRANSFORMERS

In the first network systems installed the transformers used were of the same standard type as those on the radial systems. Since that time, however, it has been found desirable to incorporate other features so that there has developed what is commonly called a network transformer particularly designed for service on this type of system.

Although only one-third of the companies operating or installing network systems have thus far decided to use any three-phase network transformers, still this number is continually increasing and there is a definite trend towards the use of this type, particularly in those systems where new transformer manholes are being built and it is a relatively easy matter to provide the larger opening required.

It is considered desirable to locate at each transformer bank some device for grounding the feeder which supplies it. A man working on the feeder cable or any of the high-voltage apparatus connected to it can then make sure that the feeder is grounded in the immediate neighborhood of the section on which he is working. The first device brought out for this purpose consisted of a small switch mounted inside the transformer.

As operating experience grew it was found that it would also be desirable to have some means of disconnecting each transformer from its feeder as an aid to testing and in order to keep any transformer out of service because of failure or for any other reason without keeping an entire feeder deenergized. This resulted in the development of the three-pole three position switch mounted in the high-voltage terminal chamber.

In the case of single-phase transformers the advantages of mounting the switches in the terminal chambers

FIG. 7—SINGLE-PHASE NETWORK TRANSFORMER USING EXTERNAL REACTORS

still exist but a somewhat more difficult problem presents itself since it is necessary to mount a two-pole switch on each single-phase unit. The San Antonio Public Service Co. decided on the use of single-phase transformers in the network system that is now being installed and rather than use a separate switch on each transformer adopted the plan of using a three-pole, three-position switch mounted apart from the transformer. A view of this switch with the front plates removed is shown in Fig. 6.

Tap changers which may be operated by handles brought through the cover of the tank are supplied in network transformers. It has been found desirable in service to have some control of the ratio of the step-down transformers and the tap changer has been adopted as the simplest means of accomplishing this with the transformer disconnected from the circuit.

One of the important questions that presents itself to any company designing a network system is the value of reactance that should be used in the network transformers. The higher the impedance of the transformers as compared to the impedance of the secondary tie cables, the better will be the load division. Since a network is designed so that any feeder and all of the transformers connected to it may be taken out of service and left out indefinitely, it is rather important that the remaining transformers share the extra load as much as possible. Besides improving the load division the high reactance also has the advantage of reducing circulating currents between feeders which in turn leads to more stable operation of the network protectors, particularly under light-load conditions. These two considerations have caused the large majority of companies operating network systems to adopt the policy of using ten per cent impedance at the transformer banks.

If a company decides to use transformers having ten per cent impedance, the next problem is to determine the most satisfactory manner in which to obtain the increased value. There are three methods that have been used up to the present time. The first method is to have the increased reactance built into the inherent design of the transformer by coil spacing and grouping. In the second method the increased value is obtained by the use of shunt iron paths in the transformer. As a third means, transformers having standard reactance may be used and this can be raised to any desired value by the addition of small reactors in the cables coming out from the transformer.

Taking all factors into consideration it would appear that the use of transformers having not more than five per cent inherent reactance, with any additional amount desired obtained by means of external reactors, is the most satisfactory arrangement for the system having usual load densities because of its flexibility.

Fig. 7 shows the low-voltage side of a single-phase network transformer and illustrates a rather convenient method of mounting the external reactors.

Present Trend of System Development

Up to the present time only one company, the Knoxville Power & Light Co., is operating an overhead automatic network system of any appreciable size. The question of using networks in such areas has been given serious consideration by other companies and it is believed that decided advances will be made in the development of such systems within the next few years.

The first two of a group of large government buildings are now under construction at Washington. The automatic network system has been chosen as the most satisfactory from an engineering standpoint as well as the most economical type of system that could be used to supply these buildings. Each building will have a secondary cable grid tying together the transformer vaults located in that building and the secondary networks of all of the buildings will be connected solidly together by low-voltage tie cables.

This development is only the forerunner of a widespread application of network systems inside large buildings if the amount of thought being given the problem at the present can be taken as a criterion. Directly connected with this subject is the one of vertical distribution in tall buildings which is being actively considered by two companies at the present time. Preliminary plans call for the location of transformers on several different floors, the group of transformers on each floor being connected into a network which may be permitted to remain independent or may be tied in on the secondary side with the networks on other floors. Along with this development, consideration is being given to every detail of the vault layout and the design of the apparatus to minimize the possibility of a transformer explosion and to localize trouble of any kind.

As a system of distribution for large manufacturing plants the a-c. network is being given serious consideration. In this field such a system should find its greatest application in those factories where the process of manufacture is such that an outage of even a short duration has serious results. A special type of automatic network system is being considered for one manufacturing plant of this type at the present time.

The network system lends itself exceptionally well to the scheme of synchronizing generators at the load. One company that is operating a large network system is now making a thorough investigation of the feasibility of such operation.

The network stands today as a type of system that has stood the test of service and has given the results expected of it. In general, the continuity of service in practically every installation has been as dependable as the source of supply and most thought is now being given to possible means of increasing the dependability of the source.

DETROIT AND CANADA TUNNEL

The first tube of the Detroit and Canada Tunnel has been sunk to a bed of mud 80 feet below the surface of the Detroit River. This tube is one of ten which will comprise the under-water portion of the $25,000,000 tunnel project. The ten tubes vary in length from 220 to 250 feet, with an over-all diameter of 35 feet. Their aggregate length is approximately half a mile, constituting the underwater part of the tunnel.

The tubes when launched weigh in the neighborhood of 500 tons each. At the time of sinking, each tube after being concreted weighs from 7000 to 8000 tons.

Abridgment of

Flying Field and Airway Lighting

BY H. R. OGDEN*

Non-member

Synopsis.—This paper discusses methods of lighting airports and airways and describes various types of lamps and equipment used for this purpose. In the information on airport illumination are included beacons, obstruction lights, boundary lights, illuminated wind direction indicators, field and building floodlights, signal lights, and ceiling illumination. The portion on airway lighting covers principal and intermediate beacons and emergency field lighting. An extensive bibliography is included in the complete paper.

* * * * *

DURING the last few years many fundamental problems of illumination for night flying have been solved by both civil and military organizations. Although the future may see considerable divergence between military and civil lighting practise, at the present time both are similar and, in fact, commercial aviation has largely followed the trend of military design.

The components of a complete lighting system for an airway and its terminals have gradually increased in number as the need for their existence has become evident through experience. Particularly is this true of the equipment at the terminal airports. The following components should be considered in planning a system for lighting a terminal flying field, in this order of importance: (1) beacon, (2) obstruction lights, (3) boundary lights, (4) illuminated wind direction indicator, (5) floodlights, (6) building flood lights, (7) signal lights, (8) ceiling projector.[8] The components of a lighting system for an airway will be given later.

If the problems confronting the night pilot desiring to land are based upon a succession of observations and decisions, we may well attack those problems in the order in which they occur to the pilot.

Airport Beacon. No mariner ever experienced greater satisfaction in identifying a lighthouse than a night pilot feels when he is uncertain of his exact location and finally espies the aerial beacon for which he has been searching the horizon. Due to lack of sufficient fuel to remain aloft, the majority of night flights must be terminated before dawn. A landing field must be located before the fuel is exhausted.

There are various types of airport beacon in use at the present time. The most common in the United States is the rotating searchlight type with a 24-in. dioptric lens, 1500-watt incandescent lamp, and parabolic reflector. An electric motor in the base rotates the light. A recent development of the light includes a lamp changer mechanism which automatically brings a new lamp into position and incandescence, at the same time giving a warning of the burned out lamp at the control office.[5, p. 2] The beam has a vertical divergence of from 3 to 4 deg., and a horizontal divergence of from 10 to 40 deg. The greater horizontal divergence increases the length of flash but decreases its intensity. This difficulty of securing great intensity and length is the only criticism that can be made against this beacon. Even with a 40-deg. horizontal divergence, the length of flash is only 1-1/9 sec. at 6 rev. per min. But the more serious fault of this periodicity is the eclipse of 8-8/9 sec. Equal periods of flash and eclipse would be more suitable but a beacon furnishing such a light appears to be more costly. A 360-deg. light house lens with revolving reflector would provide such a light.

To secure proper distribution of the lower edge of such a beacon beam along the horizon, some method of adjustment ought to be incorporated in the light, either by an adjustable pivot or an adjustable base. The latter appears to be more practical. The French are using tripod type of mount for this purpose on some of their lights.

If a water tower is located in the vicinity of the airport, it may be fitted up as a satisfactory short range beacon by painting the wall of the tank white and floodlighting it by means of sign-board flashing lights surrounding the periphery. Since such a tower would otherwise have been wired for obstruction lights to safeguard pilots from colliding with it, the cost involved comprises only the lamps, fixtures, sign-board flasher, and white paint. A sufficient number of light sources would provide against interruption of the beacon caused by a burned out lamp.

If for any airport lighting system the range of the water tower beacon is not considered sufficient, the tower may still be used to good advantage to mount on its peak any other type of flashing beacon. There are two advantages gained in mounting the flashing beacon on a tower high above the landing field. First, it allows the lower edge of the light beam to be adjusedt below the horizontal, in line with the new horizon. This gives greater range of the beacon to a low flying airplane forced to fly near the ground by low clouds. Setting a beacon 100 ft. above the ground increases its

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1. All references are in Bibliography in complete paper.

Presented at the Regional Meeting of the South West District of the A. I. E. E., Dallas, Texas, May 7-9, 1929. Complete copies upon request.

range at ground level 13 mi. Second, a flashing beacon near the ground is disconcerting to a pilot about to land. When the intense rays of the beacon strike his eyes, the pupils converge and handicap his vision. A high mount for an airport beacon is therefore a distinct advantage.

At the Croydon airport, London, a unique beacon has been tested and been found to possess unusually good visibility in thick atmosphere. It consists of a moving chain passing through a solution of strontium and then through an oxy-acetylene flame. The resultant light is very intense, but its superiority to an electric beacon does not appear to be sufficient to warrant its general adoption. In direct comparison with the strontium beacon, the Croyden airport is equipped with a truncated cone neon beacon, which is reported to pierce a small amount of fog better than any other beacon at the field.[3, p. 4]

The last beacon, and probably the favorite of night pilots, is the lighthouse type of beacon with 360-deg. Fresnal lens units. For the same power input, these beacons do not have the range of the searchlight type due to the fact that the light is diffused over 360 deg. as compared to from 10 to 40 deg. for the searchlight type. But on the other hand, the lighthouse beacon can be designed to give any type of flash desired. The largest beacons of this type are located in France, one near Paris and one near Dijon. Each has 1,000,000,000 cp., sufficient to give a range of visibility of 100 mi. in clear weather.

To sum up the present practise in the use of airport beacons, the projected beam type is most common in the United States, the Fresnal lens lighthouse beacon is favored in France,[4, p. 1] while the flashing neon beacon is extensively used in Germany.[4, p. 3] England, also, is partial to the neon beacon due to the claim for its fog piercing quality. Since the Fresnal lenses are expensive to manufacture while the neon tubes are expensive to operate, it is evident that European practise in night lighting does not consider the cost so important as superiority of equipment.

Obstruction Lights. After a pilot locates his landing field through the aid of the airport beacon, he approaches the field and observes obstructions which he must avoid while examining the landing area, the wind direction indicator, and ships about to land or take off. Crashes which occur through colliding with other airplanes near the ground or with obstacles while still in flight are usually fatal to the occupants. The obstruction lights are therefore very important in any plan for lighting an airport. A careful analysis must be made of the probability of an airplane colliding with any obstacle within a half mile of the field, and other obstacles farther away which are on the direct line of an airway. It is reasonable to assume that no pilot will fly lower than 100-ft. altitude until actually making his approach for landing. Ordinarily, no obstacles less than 50 ft. high, which do not immediately surround the field, need be lighted. However, each field presents special problems, and no set rule can be made. It should be borne in mind that an airplane glides at an angle never steeper than 1 to 5. This will indicate roughly what structures or natural objects in the vicinity of an airdrome should be considered obstructions. A compromise between ultra safety and cost must always be made. Poor pilots will sometimes hit obstacles in spite of everything that can be done to safeguard them.

The universal practise in Europe and America follows the recommendations laid down at the International Air Convention for marking obstacles with red lights. The Material Division of the Air Corps recommends the use of 50-watt lamps in ruby globes of high light transmission qualities.[6, p. 4] The lights burn steadily and may be connected with the field lighting circuit. The lamp fixtures should be placed so that the obstacle light can be seen from the horizontal to the zenith in all directions, and from the ground anywhere on the airdrome.

Boundary Lights. When the pilot of an airplane has observed all obstructions about a field upon which he intends to land, his next observation is usually to determine the extent and nature of the field. Boundary lights can answer both of these questions. The Department of Commerce has made a careful study of the boundary light problem and has published the results in Aeronautics Bulletin No. 2.[1, p. 12] That bulletin should be consulted in drawing up a plan for an airport lighting system.

The general practise for placing boundary lights is to outline the field completely except along the hangars, outline just the corners of the field, or outline the runways. The last method is most expensive, and, in the case of raised lights, invites collision from a rolling airplane. However, with the lights installed flush with the ground or raised only a few inches, permitting an airplane wheel to roll over without damage, this system has a distinct advantage. It enables the field manager to indicate clearly the best approach and best place to land under various wind conditions by merely lighting the one runway which should be used.

A special plea is made for the design of boundary lights which are fairly indestructible. The present practise of installing a lamp 1 to 3 ft. above the ground on the top of a pipe set in concrete[1, p. 12] has one insurmountable drawback. The installation attracts the attention of curious people, and invites malicious people or undisciplined children to break or pilfer the globes and lamps. No measure short of a constant guard near such boundary lights will protect them from depredation. Landing fields are too large for a manager on one side of the field to be responsible for the protection of the boundary lights on the opposite side. The design of lights flush with the ground will not attract so much

attention, and it is believed that they can be made fairly indestructible, at the same time fulfilling the purpose for which they are installed.

Another advantage can be gained by using boundary lights flush with the ground. Instead of establishing a row of lights on the very edge of the landing area, such a row could be placed 300 ft. from any edge along which a telephone or power line was located. Thus, a normal glide to the edge of the boundary lights would insure the pilot's clearing the poles and wires by a safe margin. In addition, lights placed away from the edge of the field would be less conspicuous and less likely to be molested.

Illuminated Wind Direction Indicator. Normal landings are always made into the wind in order to reduce the ground speed of the airplane as much as possible and retain directional control after the airplane is rolling on the ground. To indicate the direction of the wind to the pilot about to land, several devices are in use. For daytime operation, a wind cone of fabric attached at the larger end to an iron ring free to rotate about a vertical axis, and tapering from about 2-ft. diameter at the ring to 1-ft. at the smaller end, has been in use since the beginning of heavier-than-air flying. The first illuminated wind direction indicators naturally were developments of the wind cone. One authority maintains that illuminated wind cones are not satisfactory,[6, p. 5] but a number of internally illuminated wind cones have been in service at a large Air Corps field for nearly a year and have given uninterrupted satisfactory service.[7] Such indicators are unquestionably the cheapest to install and maintain.

Another type which is popular in England and Germany is a system of lights sunk flush with the ground level, so controlled by either a wind vane switch or manual operation in the administration building that an illuminated T is visible to the pilot.

The best military practise in America calls for an externally illuminated T situated on the ground in front of the operation office of the field. It consists of a skeleton framework built in the shape of a T, carrying a vertical fin at the base of the T to hold the head of the T into the wind, all covered with airplane cloth, and suitably finished.[6, Fig. 6] It is supported horizontally above the ground on a pivot located at the center of gravity. The illumination is provided by two rows of 10-watt lamps located on top of the T. The current is transmitted through a brush arrangment on the supporting bearing. For night visibility the best color for the T is white, whereas for daytime visibility the most satisfactory arrangement developed to date is a chrome yellow T riding a cement or wood background painted black. A good compromise would be a white T on a black background.

The best practise seems to indicate a single wind-direction indicator suitable for both day and night, either an illuminated wind cone or illuminated *T.* The latter is visible a greater distance, and therefore is more satisfactory to the flight leader of a formation of airplanes. The former is more economical and ought to fulfill the needs of most civil airports when properly designed.

Floodlights. No component of airport lighting systems has received so much attention and been the subject of so much experiment in this country as the airport floodlights. The problems connected with floodlighting have been many. At the same time, an airplane properly equipped for night flying is less dependent upon floodlights than upon several of the airport lighting components generally considered less important. Landing lights now available for installation on airplanes, developed by the Materiel Division of the Air Corps, make landing at night reasonably safe when the landing field is properly boundary lighted. However, floodlights must be available in an emergency, and floodlights also improve the ability of a pilot to judge his height above the ground.

Since the manner in which a pilot should pass floodlights in landing is an important factor in determining where the lights should be placed, considerable experimenting has been done along this line. Some pilots recommend that the pilot glide down to a landing over the light and parallel to the beam; others, that he glide diagonally across the beam from the rear; and still others recommend that a landing be made perpendicular to the beam. However, the last recommendation is based upon the use of a single light source of the 180-deg. Fresnal lens lighthouse beacon type, or a battery of projectors arranged along the side of the field. The disadvantage of the first method is that when the airplane enters the beam near the ground, the pilot is suddenly confronted with the shadow of his airplane extending far out in front of him. This disadvantage becomes less annoying as the path of a landing airplane is changed to a perpendicular to the light beam. No one recommends landing into the glare of a light.

For several years the students at the Air Corps Advanced Flying School have been landing straight down, or diagonally across the rear of the beam from a 500,000,000 high-intensity arc, whose beam had a 40-deg. lateral divergence and a 4-deg. vertical divergence. No difficulties have been experienced, and the embryo pilots found the landings quite easy. However, recent experiments at Wright Field, the home of the Air Corps Materiel Division, indicate that even better results can be obtained by greater lateral divergence of the beam and landings made perpendicular to the principal axis of the beam. If the foregoing premise is accepted, then the floodlighting of any field to take care of various wind directions resolves itself into the use of two light sources or two batteries of light sources on adjacent sides of the field. Only the light from one side of the field will be operating at any one time and landings can be made either parallel to that side or diagonally away from it. The arrangement of floodlights is discussed and illustrated thoroughly in

the Department of Commerce Aeronautics Bulletin No. 2.[1, p. 14]

The practise followed in the design of floodlights has been in the direction of two entirely different types of light units. Experiments in America for a number of years were restricted, for lack of funds, to the searchlight type. Many of these units were manufactured during the World War, and were available for experiment. A 36-in. drum with a parabolic reflector and a high-intensity arc light source was fitted with a dioptric lens which diverged the light beam laterally to a 40-deg. spread. This unit required the constant attention of an operator, the light emitted was not always steady, and when the arc had to be replaced a serious interruption of the light ensued. The first improvement of the unit consisted in substituting a 10-kw. incandescent lamp for the arc. The new light source did not have the same candlepower as the arc, nor was the color of the light so good, but the rays were steady, a prompt lamp change could be made, and the quality of the light was satisfactory. The last major improvement was the incorporation of a lamp changer mechanism which automatically brought a new lamp into position and incandescence, and gave a warning signal in the control room when a lamp burned out. As a single narrow beam, single source floodlight, this unit is very satisfactory.

However, such a unit lights only a limited portion of the landing area. The advent of formation flying at night will require a wider distribution of light. To secure a greater light spread would require a battery of such lights, the combined over-lapping light of which would be much more intense than necessary. To secure a sufficient spread of light at a reasonable cost would require either a new type of single source light with a larger lateral divergence, or a battery of smaller projectors.

European practise invited the attention of American engineers to the 180-deg. Fresnal lighthouse lens floodlight which has been tested comparatively with various types of floodlights[12] and found to be superior for the operation of airplanes in formation. A low mounting of the light, with a sharp cut-off on the upper edge of the beam, produced the most favorable illumination. One objectionable feature of this installation is that irregularities in the surface of the landing field produce shadows.

To overcome this serious objection on irregular fields, a battery of six smaller 24-in. drum projectors with parabolic reflectors, 1500-watt lamps, and 40-deg. dioptric spread lens can be mounted on 10- to 15-ft. standards and spaced 200 to 300 ft. apart along the side of the field. This equipment is much less expensive than the single source lighthouse lens floodlight, is preferable for irregular surfaced fields, and is therefore to be recommended for moderate sized airdromes from which airplanes operate one at a time.[12, p. 6] The cost of lighthouse lens units will probably limit their use to military airdromes and major terminals, while the coming host of smaller municipal airdromes will be equipped with batteries of 24-in. projectors. The present equipment which is being manufactured for flood lighting needs only to be installed properly to give entire satisfaction. Many refinements will be made in the future, but at least the fundamental problems have been solved.

Airway Lighting. The components of an airway lighting system are; (1) principal flashing beacons, (2) intermediate beacons, (3) emergency field lighting. Practise in airway lighting in Europe and America has been widely different, but as time goes on, the respective systems are growing more similar. Europe began lighting its airways with widely separated beacons of tremendous candlepower. Two beacons are 1,000,000,000 cp. each, located at Mount Valerien and Mount Afrique in France. Moderate sized intermediate beacons are located at the terminal airports,[4, p. 20] and still smaller beacons are being installed along the routes. In Germany, the majority opinion favors comparatively low power lights at frequent intervals from 1 to 2 mi. apart.[4, p. 4] On the Berlin-Konigsberg and Berlin-Amsterdam routes are used double series of neon lights which burn continuously night and day. Operation cost of each light is claimed to be about one dollar per month.

American practise began with the installation of beacons spaced close together, though not so close as in the present German practise. And now larger beacons are gradually being used at major terminals to supplement the small beacons.

England has favored the automatic unattended gas lights,[4, p. 11] for aerial route beacons, and the Bureau of Aeronautics in our Department of Commerce has installed these beacons on some of the air mail routes where electric power is not available and the lights must operate unattended for long periods of time.

Emergency landing fields are being established at approximately 25-mi. intervals along the air mail routes. Most of the flashing beacons are located at these emergency fields. The lighting equipment in addition to the beacon consists of boundary and obstruction lights, and an illuminated landing T.

Future Developments. The impetus which Congress gave to aviation through the establishment of a Bureau of Aeronautics in the Department of Commerce has been very great. The increase in night flying, encouraged by the night air mail and the installation of airway lighting, has been remarkable. Although the fundamental problems of aviation lighting have been solved, much important work lies ahead. As already mentioned there will probably be a continual divergence in practise between the requirements for civil aviation and military aviation. Two factors dictate this divergence; utility and cost. Night flying in the Army and Navy will develop into the operation of groups of

airplanes as opposed to airplanes operating singly, so that flood lighting systems will probably be designed along two different lines. Also, military aviation will require mobile lighting units as well as permanent peace time installations, and therefore the development of dual equipment will require larger expenditures for military lighting than for civil. However, as will be noted in this paper, those who are charged with the design and installation of lighting equipment for private, municipal, and federal airports and airways will continue to draw upon the knowledge acquired and experience gained by the pioneering work of the military services, and particularly in this country by the Materiel Division of the Air Corps. It is vitally necessary for the military services to pioneer in the development of material which will improve the system of national defense. It is also reasonable that where such development is useful to civil progress, the knowledge gained through the expenditure of public moneys should be extended freely to the public when not inimical to the security of the nation. Such are the conditions surrounding the development of almost all aviation lighting equipment by the U. S. Air Corps. When the business of furnishing lighting equipment to civil enterprises grows to larger proportions we can look for great experimental work to be done outside of the Army and Navy. That such a time will come is certain. The Army has for several years been drawing upon the ideas of commercial airplane designers for improvements in airplanes, and the day is not far distant when very superior aviation lighting equipment will be designed for civil use.

Abridgment of

Bessel Functions for A-C. Problems

BY HERBERT BRISTOL DWIGHT*

Fellow, A. I. E. E.

Synopsis.—Tables of Bessel functions of zero and higher orders are given for use in problems of skin effect and proximity effect in conductors carrying alternating currents. Formulas for deriving numerical values of the functions are given in the form of series for large and for small values of the argument. The series are complete with their general terms. The application of the tables to the calculation of the skin effect resistance ratio of an isolated tubular conductor is described and an example is given.

* * * * *

THE behavior of alternating current in a round conductor or in groups of round conductors is calculated by means of Bessel functions. Such problems are usually known as skin effect and proximity effect problems. The division of current between conductors connected in parallel, (or in other words, the circulating currents in parallel conductors,) the distribution of current over the cross-section of the conductors, the watts loss in each conductor, the resistance drop and the reactance drop, are characteristics which are desired to be known and which can be calculated for round wires.

Such problems occur in electrical engineering where heavy alternating currents of more than about 1000 amperes at 60 cycles are involved. When it is remembered that generators for power stations sometimes have a rating of 5000 amperes or more, and that electric furnaces up to 50,000 amperes capacity are built, it is evident that these problems occur in practical engineering. Small conductors carrying currents at radio frequencies require calculations similar to those for large conductors carrying 60-cycle current.

In this paper is presented a collection of available numerical values of Bessel functions of argument $x\, i \sqrt{i}$, which are used in the classes of problems described. Bessel functions of the first and second kinds, of zero order and of higher orders, and for values of x up to 10, are included. Series are also given, some of them of new form, for calculating additional values.

*Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts.

Complete copies upon request.

PHOTOELECTRIC TUBE COUNTS TRAFFIC PASSING THROUGH HUDSON TUNNEL

Every automobile passing through the Holland Tunnel under the Hudson River between New York and New Jersey is now registered at the exit by an electric traffic checker. The device works 24 hr. a day, never missing the count, which is recorded instantly upon a dial in the administration building of the Tunnel Commission at Varick and Canal Streets in New York City. The apparatus consists of a small floodlight mounted in an inclined position upon the overhead ironwork of the exit. A slender beam from the light falls upon a small circular window in a box placed beneath the sidewalk at the opposite side of the roadway. The box contains a sensitive photoelectric tube, an amplifying tube, and an electrical relay. When a vehicle passes, the beam is interrupted. The photoelectric tube is affected so that a slight electrical impulse results. This is amplified by the vacuum tube and fed to the relay, energizing a transmission circuit, the other end of which is in the commissioner's office. A dial there, actuated by the electric current, registers another figure in response to each impulse from the relay.—*Telephone and Telegraph Age.*

ILLUMINATION ITEMS

Submitted by

The Committee on Production and Application on Light

AVIATION LIGHTING

By L. C. Porter*

The American public is rapidly becoming air-minded, and the result is that aviation is advancing faster than any previous method of transportation. Like all other modes of travel, if aviation is to succeed commercially, operations must extend into the night. Night flying necessitates lighted airways and lighted airports. Great progress is being made along those lines. Guided by Government practise, the art of lighting is becoming standardized very rapidly.

The lighting of the airways is installed and maintained by the Government in much the same manner that lighthouses, buoys, etc., are operated. The principal lighting unit on the airway consists of a 24-in. rotating searchlight equipped with a 1000-watt Mazda lamp and producing a 5-deg. beam of about two million candlepower. The speed of rotation is six rev. per min. In the latest beacon an auxiliary lens is placed in the top of the beacon to produce an upward fan of light for an indication when a flier is directly above the beacon. The rotating beacons are supplemented by smaller fixed searchlights, trained up and down the course, which flash the number of the beacon. They are called "course lights."

There are also emergency landing fields along the airways, having illuminated wind cones, obstruction and approach boundary lights.

The lighting of the airports is generally a municipal job. There seem to be two general methods in vogue. One is by the use of a number of relatively small floodlights equipped with 1500- or 3000-watt lamps. These may be either grouped or distributed along two adjacent sides of the airports. The other method is the use of one or two very high-power field floodlights. There are three types of these in use. One consists of a large Fresnel type lens equipped with a 150-ampere high-intensity arc or a 10-kw. Mazda lamp.

Another type of unit that has proved very successful consists of two 10-kw. Mazda lamps backed by searchlight mirrors and equipped with lenses to spread the beam into fan shape over the field. The latest unit consists of a set of parabolic cylinder reflectors equipped with a number of 3-kw. Mazda lamps.

In addition to the main field floodlights, there are white boundary lights to outline the field; green lights to indicate the best direction of approach, red lights to mark obstructions, a rotating beacon and an illuminated wind indicator. Most fields also have floodlighted hangars, a ceiling projector and an illuminated sign.

*Engineering Department, Edison Lamp Works of the General Electric Company, Harrison, N. J.

The greatest hazard in flying today is fog. Many extravagant claims have been made on the fog penetrating ability of neon light. It is claimed to have some peculiar characteristic which other forms of red light do not possess. In this connection, it is interesting to note the conclusion reached by the U. S. Bureau of Standards after making a most exhaustive study of the relative merits of a neon beacon *vs.* a Mazda lamp equipped with a red color screen. We quote from the *Technical News Bulletin* of the Bureau of Standards, Nov. 1928, No. 139 as follows:

"Observations were made with the naked eye and with a photometric wedge. No differences sufficiently great to be detected by the methods used in this test were found between the visibility of light from a neon lamp and the light of the same color, candlepower, and horizontal distribution produced by an incandescent filament lamp with color screen.

"With regard to the comparison of the clear incandescent lamp and incandescent lamp with red color screen, the red filter does not increase the range under any weather conditions, but there is some evidence that the red filter does not reduce the range as much in foggy weather as it does in clear weather."

A great deal of interest has arisen in air marking signs to mark the airways and name the towns. Several systems are in use, *i. e.*, floodlighting, neon tubes, and exposed Mazda lamps. In this connection, the U. S. Department of Commerce, Airways Division, has just completed an exhaustive test on the relative legibility of various types of signs. We quote from their report.

"Illumination by direct light is the most effective owing to greater brilliance and hence greater attracting power. Markings illuminated in this manner are effective at night even though the color of the characters is obscured by dirt or snow.

"For outlining with incandescent lamps, not less than 10-watt sign lamps should be used and they should be spaced from 8 in. apart for 6-ft. letters to 12 in. apart for 12-ft. letters or larger. Unless there is a large amount of competing light in the vicinity of the marking, the 10-watt lamps give better legibility than lamps of higher wattage. In case it is desired to use colored lamps with a brilliance corresponding to the 10-watt clear sign lamps, 25-watt lamps should be used for green and red and 50-watt lamps for blue."

A very effective air making sign consisting of a big 100-ft. arrow made up of standard parts, has been perfected. Plans are under way to carry out a nation wide marking of the airways with signs of this type.

Several good articles on aviation lighting have appeared in the transaction of various engineering societies, and in the technical press, going into great detail in aviation lighting. In this article we have therefore only mentioned the latest developments.

LIGHT AND ARCHITECTURE

By A. L. Powell*

It is quite natural for new schools of thought in design, decoration, and architecture to originate in continental Europe. The atmosphere, background, and tradition of the larger cities are all conducive to this end. Within the last half century, or even since the beginning of the 20th century, our very habits of living have undergone remarkable changes. The mechanical element in the production of all sorts of objects has come to the foreground. Speed of transportation has greatly increased. With mass production, things formerly considered luxuries have become necessities and the spirit of the age such as to make a new school of architecture and decoration come into being. The recent war, demanding practically all the thought and energy of the entire world, made it impossible for even the artist to sit back and dream of his problems. After the close of the war there was a brief period of reconstruction, but by about 1924, clever minds began to evolve a new school of decoration. For want of a better name, this has been termed "art moderne."

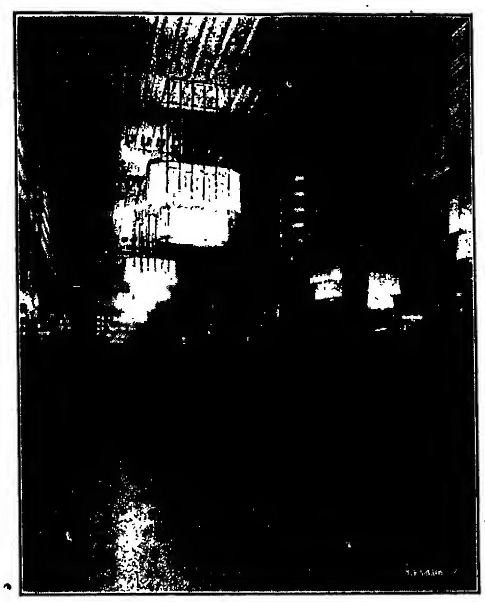


Fig. 1—The Entrance Corridor of One of the Newer New York Office Buildings

It is interesting to note how the decorative lines have been carried out in the luminaires. Even the very method of support bears little resemblance to the types which were familiar a few years ago

In the Paris Salon of 1924 were exhibited a few examples of this trend in design. The International Exposition of Modern Decorative and Industrial Art in Paris, 1925, was literally filled with further developments. From France, the idea extended to Germany, England, Italy, and other parts of Europe. Many delegates, artists, architects and designers from the United States at once saw the application of this unique treatment to American conditions and we now have some excellent examples in this country. For example, the sky-scraper is distinctly American in character and feeling, and this new school of decoration seems to have embodied in it very much of the same spirit.

Some of the original designs of the French were unquestionably extreme and did not appeal to our taste. Many of the German modifications are even more bizarre, but it may safely be said that most Americans who have adopted this treatment have done a most commendable job. They have to a great degree eliminated the ultra-fantastic element and created something distinct and adapted to our taste. They have grasped the fundamental principles and developed these along rational lines. Practically every new commercial building now being erected, or even contemplated, particularly in the vicinity of New York, has some of this modern treatment incorporated in it.

Lighting plays a very important part in "art moderne." Some of its very first applications were to luminaires or fixtures. The Germans have incorporated light in this new art to such a remarkable degree that they have coined a term "Licht Architektur" (light architecture) as applying to those structures where light is utilized in novel manners. At last we are seeing the lighting planned as a component part of the structure, or the luminaire carrying out in line and decoration the spirit expressed in the architecture.

Fig. 2—A Bank Interior with Luminaires of Unique Designs Which Conceal All Lamps from View

These are almost entirely of glass and being of low brightness, are beautiful lighted ornaments. The real working illumination comes from large lamps in indirect reflectors on pedestals around each column

This movement is most encouraging to the lighting engineer, for he has been preaching for a long while that incandescent lamps are indeed radically new light sources and need not be handled in the traditional or classical manner. In the days of flame illuminants, it was necessary to have the light source at some distance from surrounding objects to prevent fire. It was necessary to take care of the products of combustion, to provide ventilation, and in the case of candles, to have some

*Research Laboratory, General Electric Company, Schenectady, New York.

means of catching the dripping wax. It is quite ridiculous to place Mazda lamps on the end of paper tubes and attempt to simulate candle lighting. It is almost as illogical to use chandeliers of the types designed for gas jets.

The incandescent lamp can be burned in any position;

FIG. 3—A DISTINCTIVE STORE INTERIOR WITH GLASSWARE MADE BY THE FAMOUS FRENCH ARTIST, RENE LALIQUE

it can be entirely enclosed; it may be recessed in a wall pocket; it may be concealed within a structural member and its light emitted through diffusing or diffracting windows. There is literally no end to the manner in which it may be employed. The ingenious designer

FIG. 4—ONE OF THE NEWER TYPES OF SHOW WINDOWS EMPLOYING GENERAL OVERHEAD LIGHTING PLUS SOME FIXTURES OF LOW BRIGHTNESS AND LIGHTED DISPLAY STANDS

may let his imagination run far afield and electric lighting will enable him to carry out his most imaginative scheme. This new art takes full advantage of the imagination and, while at present still in the embryonic or formative state, it has already produced numerous examples of truly unique ways of supplying artificial light. It is essentially a young man's movement. It will be difficult for the older designer, steeped in classical traditions, who all his life has been copying 18th and 19th century fixtures, to get this radically different

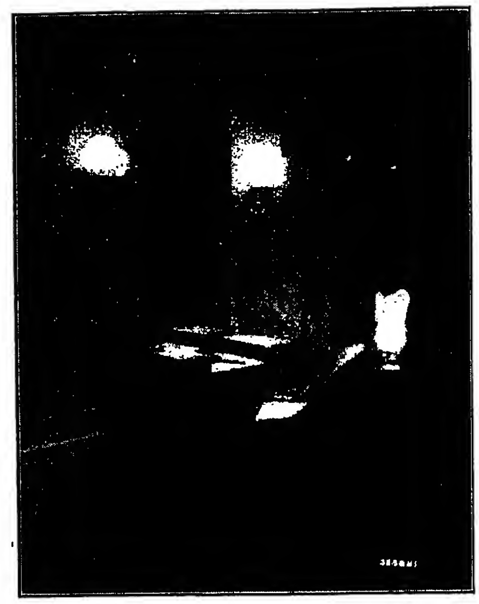


FIG. 5—A CORNER IN AN EXCLUSIVE MILLINERY SHOP ILLUSTRATING THE USE OF AMERICAN MADE LIGHTING EQUIPMENT ALONG MODERNISTIC LINES

The designs are very simple, consisting of planes of frosted glass held by a wrought iron framework. The modern Mazda lamp does not need to be applied at the end of an imitation candlestick and should be used in a 20th century manner

point of view. Some of the examples are indeed extreme in character and unquestionably will not live. Most of them, however, have the germ of an advance and are

FIG. 6—READING ROOM IN THE PANHELLENIC BLDG., 49TH ST. AND 1ST. AVE., NEW YORK CITY

to be commended. Out of the stress will come something of which we will be justly proud. We are seeing the beginning of a new school just as surely as Europe saw new ideas introduced at the Renaissance.

INSTITUTE AND RELATED ACTIVITIES

The Summer Convention at Swampscott

The activities of the A. I. E. E. Summer Convention at Swampscott, Mass., start simultaneously with the printing of this issue of the JOURNAL, and the detailed account of this meeting will therefore have to be deferred until the issuance of the August JOURNAL. The plans formulated by the Convention Committee for this occasion, however, have been so comprehensive that there can be no doubt that the traditional success of our Summer Conventions will be maintained. The completed program for the technical sessions is even fuller than usual, necessitating several parallel sessions; and the sports and entertainments offered are more than ample to occupy every moment available for recreation.

Pacific Coast Convention Papers Deal With Live Problems

A technical program which will deal with some of the most active problems of electrical engineering is being arranged for the Pacific Coast Convention of the Institute, which will be held September 3-6, at Santa Monica, California, with headquarters at the Hotel Miramar.

The subjects to be covered in the technical papers include several phases of transmission, insulator flashover, wood pole insulation strength, series synchronous condensers, system stability, transformers, high-voltage fuses, insulating oils, arcs, electrical conductivity, gas-filled tubes, radio interference, sound pictures, dial telephony, population forecasting, wind tunnel equipment, turbo-generators, a-c. networks.

The following are the title of papers which have been proposed; more information will be given in the August issue of the JOURNAL:

SUBJECTS PROPOSED FOR PACIFIC COAST CONVENTION

Radio Interference from Line Insulators.
Spray and Fog Tests on 220-Kv. Insulators.
The 60-Cycle Flashover of Long Suspension Insulator Strings.
Impulse Insulation Characteristics of Wood Pole Lines.
Recent Developments in the Theory of Electrical Conductivity.
Development of Insulating Oils.
Effect of Tank Color on Temperature of Transformers under Service Conditions.
Population as an Index to Electrical Development.
Flames from Electric Arcs.
Design Features That Make Large Turbine Generators Possible.
Effects of Surges on Transformer Windings.
An A-C. Low-Voltage Network without Network Protectors.
Development of Low-Current, High-Voltage Fuses.
Neon-Filled Tubes and Their Characteristics.
Electrical Control Features of Wind Tunnels.
The Electrical Engineering of Sound-Picture Systems.
Dial Telephone System Serving Small Communities of Southern California.
Parallel Operation of Transformers Whose Ratios of Transformation are Unequal.
Relation of System Connections and Apparatus to Stability.
Series Synchronous Condenser for Transmission-Line Regulation.

World Engineering Congress Program Progressing

Among the many papers dealing with electrical engineering progress in the United States, scheduled to be submitted by American delegates to the World Engineering Congress in Tokio next Fall, are "Extra High-Voltage Transmission," by J. P. Jollyman and E. R. Staffacher, "Interconnection of Electric Systems," by Farley Osgood, P. M. Downing, W. E. Mitchell, and E. C Stone, "Résumé of the Stability Problems as Applied to Long Distance Transmission of Power," by Charles Le G. Fortescue, "Remote Operating Supervision and Control of Electric Power Stations and Substations in the United States," by Chester Lichtenberg and Ferdinand Zogbaum, "Economic and Operating Considerations in Railroad Electrification in the United States," by Dugald C. Jackson, and "High-Tension Cable Specification and Design in America," by William A. Del Mar.

Other papers to be read by American delegates to the Congress are: "The Rapid Transit Subways of New York" by Robert Ridgway, "Municipal Engineering in the United States" by C. E. Grunsky, "River and Harbor Engineering in the United States" by Edgar Jadwin, "Ventilation of Vehicular Tunnels" by Ole Singstead, "The World's Iron Ore Supply" by C. K. Leith, "Refrigeration in the Preservation of Food" by Harden F. Taylor, "Safety in Dam Construction" by Allen Hazen, "Development in the American Coal Industry, 1913-28" by George Otis Smith and F. G. Tryon, "Suspension Bridges" by Ralph Modjeski, and "Petroleum" by Mark L. Requa. Doctor F. B. Jewett, Doctor Elmer A. Sperry, Doctor W. C. Whitney and F. W. Peek, Jr. will also be contributors.

Arrangements for the transportation of American engineers and European delegations were announced June 29 by Maurice Holland, Executive Secretary of the American Committee of 80 engineers and scientists sponsoring participation of the United States in the Congress.

A second ship has been engaged to transport the official delegates from America and Europe, who with their families will number close to 300. The official ships, S. S. *President Jackson* of the Dollar Line and S. S. *Shmyo Maru* of the Nippon Yusen Kaisho Line will depart from San Francisco on October 10.

Engineering Experiment Station Record

The Engineering Experiment Station Record Summary for 1929 now available at $1 per copy by application to R. A. Seaton, Dean and Director, contains carefully prepared data on many live research projects, administration, organization, funds, employees, channels of publication, bulletins and circulars issued, and other data on engineering research at each of the land-grant colleges and universities in the United States.

From the table given it will noted that there are now 38 definitely organized engineering experiment stations in the land-grant colleges and universities; definite provision is made for engineering research in several additional land-grant institutions, and a total of $1,440,018 is available for engineering research in these institutions for 1928-29; 925 persons are engaged either full-time or part-time upon engineering research and that 1263 engineering research bulletins or circulars have been issued.

The record is published by the Engineering Experiment Station Committee of the Association of Land-Grant Colleges and Universities, data being submitted by the directors of the experiment stations and deans of engineering and rechecked by the deans and directors. It is, therefore, most complete and an accurate summary of engineering research in the land-grant colleges and universities that has yet been issued.

While this Summary has been issued primarily for the use of research workers in the engineering field it contains much material of interest and value to others engaged in engineering and educational work. Only a limited number of copies are available at the present time.

Harold B. Smith

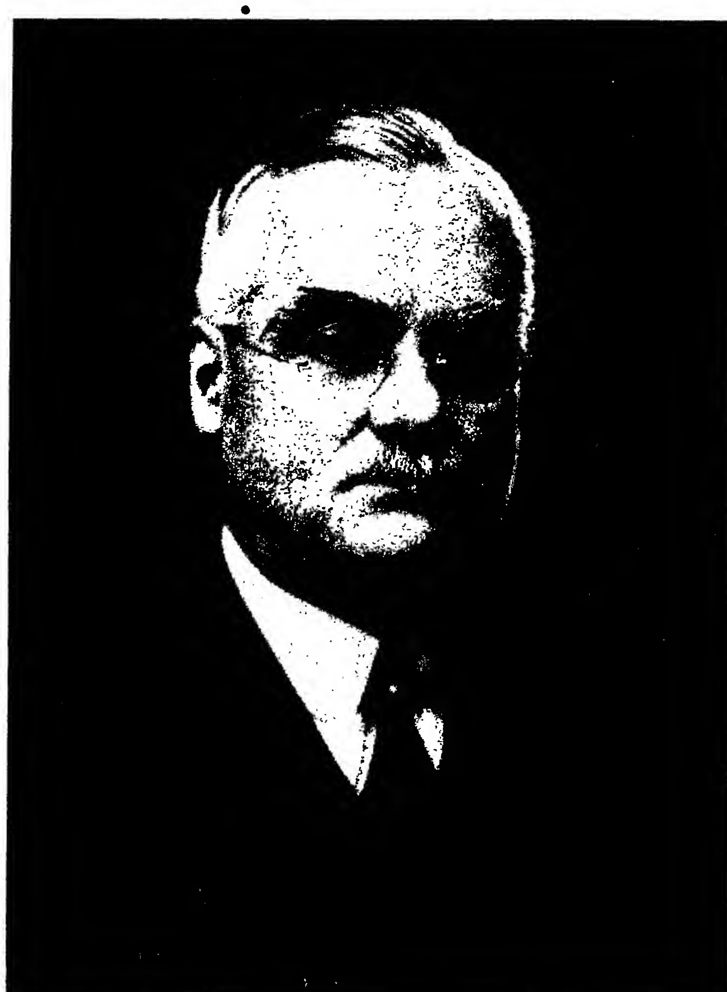
President-Elect of the A. I. E. E.

Harold B. Smith, Professor of Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass., and Consulting Engineer, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., was elected President of the American Institute of Electrical Engineers for the year beginning August 1, 1929, as announced at the Annual Meeting of the Institute held at Swampscott, Mass., June 25, during the annual Summer Convention of the A. I. E. E.

Professor Harold Babbitt Smith was born at Barre, Massachusetts, May 23, 1869. He was graduated from Cornell University with the degree of M. E. in Electrical Engineering in June 1891, but remained as graduate student until December 1891.

In January 1892 he was appointed Professor of Electrical Engineering in charge of the department at the University of Arkansas. Resigning from this position in December 1892, he became Head Designer and Electrical Engineer for the Elektron Manufacturing Company, Springfield, Mass. From September 1893 to June 1896 he was Director of the Department of Electrical Engineering at Purdue University. He has held his present position as Professor of Electrical Engineering and Director of the Department at Worcester Polytechnic Institute since 1896.

Professor Smith retained a connection with the Elektron Manufacturing Company as consulting engineer until 1902, and did consulting work for several other organizations at various times. Since 1905 he has served as a consulting engineer for the Westinghouse Electric and Manufacturing Company.



Harold B. Smith

He was Chairman of the International Group, Jury of Awards in Electrical Engineering at the St. Louis Exposition in 1904. During the years 1917-19, he was an associate member of the Naval Consulting Board and consultant of the Special Board of the Navy on Anti-Submarine Work.

He has been a pioneer in the development of high-voltage power transmission systems and equipment, has carried on many researches involving advanced conceptions of dielectric phenomena and stress distribution, and holds numerous patents. He has contributed many papers to the transactions of the societies and other engineering publications.

Professor Smith's Institute activities are as follows: Associate 1891; Member 1901; Fellow 1913; Director 1920-24; Vice-President 1924-26; Chairman of Sections Committee 1924-27; and member at various times of the Coordination Education, Electrophysics, Law, Instruments and Measurements, Sections, Student Branches, Edison Medal, Research, Meetings and Papers, and a number of special committees. He is at present Chairman of the Committee on Code of Principles of Professional Conduct.

His other memberships include American Society of Mechanical Engineers (Member), Institution of Electrical Engineers (Great Britain), Society for the Promotion of Engineering Education, American Association for the Advancement of Science, Sigma Xi, and Tau Beta Pi.

Engineers to Award Their First Welfare Medal

At some time during the current year there will be presented by the American Association of Engineers, the first Clausen Medal, of which subsequent annual awards will be made to the engineer who, during the preceding year, "has accomplished distinguished service in the welfare cause —social or economic or both." The movement is sponsored by H. A. Wagner, a national director of the Association, and this year's committee of judges of award is composed of such men as G. M. Butler, Dean and Director of Engineering University of Arizona; L.W. Baldwin, President of the Missouri Pacific Lines; J. W. Thomas, Vice-President of the Firestone Tire and Rubber Company; C. F. Kettering, General Director of the General Motors Research Laboratories; Rufus B. von Kleinsmid, President of the University of Southern California; Michael I. Pupin, Research Laboratory Department of Physics, Columbia University; A. E. Morgan, President of Antioch College; W. L. Saunders, Chairman of the Board, Ingersol-Rand, New York; G. C. Warren of Warren Brothers Company, Boston, and A. N. Talbot, Professor Emeritus, College of Engineering, University of Illinois. The medal is named in compliment of Henry W. Clausen, of Chicago, who has given the Association such commendable service for the past 15 years in various executive capacities. It bears the inscription "Award in recognition of a signal public service. Designed to mark the

entrance of the American Association of Engineers into the field of welfare."

The Faraday Medal to Doctor Semenza

In April 1929, Doctor Guido Semenza, Local Honorary Secretary of the Institute, Milan, Italy, was made the recipient of the Farraday Medal, an honor of outstanding scientific distinction, conferred by the Institution of Electrical Engineers of Great Britain.

Guido Semenza was born December 19, 1868 in London, but of Italian parentage. His father was a prominent patriot during the period of the independent wars, and was a great friend of Mazzini and Garibaldi; he also helped materially in the revolutionary movements against the oppressors of the people of Italy. Guido, as a child, returned to Italy with his parents, where his early education and classical studies began, and in 1893 he received his degree as industrial engineer at the Politechnic School in Milan. Subsequently he received another degree in electrical engineering at the Institute Montefiore in Liege. The following year he became associated with the Edison Company in Milan, when it was starting the study of the Paderno plant, which was the pioneer hydroelectric plant in Europe. Here he assumed the supervision of the electrotechnical construction and also projected and directed the construction of the high-tension transmission line to Milan. He remained with the company until 1917 as Chief Electrical Engineer.

During his connection with the Edison Company, his services as a consulting engineer were very often sought by other companies and he became one of the principal consulting engineers of his country. He has also often been called upon in a consulting capacity by companies in foreign countries, principally in Zurich, Clermont Ferrand, London, Brussels, Odessa, Detroit and in various places in Brazil. With the assent of the managers of the Edison Company, he was called in 1904 to direct the activities of the Societa Alta Italia. He remained with the company as Manager until the telephone systems were taken over by the government in 1907. During this time he also served as a member of the Board of Directors of many Electrical Companies. In 1923 he succeeded in enlisting the necessary support and reorganized the company known as the C. G. S. (formerly Olivetti), manufacturing electrical instruments. He became its President and in a very few years it reached a high degree of prosperity.

He was one of the founders of the A. E. I., of which from 1915 to 1917 he was President, and during his incumbency, notwithstanding the difficulties of the war, the Association developed greatly. He was also one of the founders of the I. E. C., to which, since its inception, he has given generously of his time and advice. In this connection, he has been for many years President of the Italian Electrotechnical Committee and in such position has maintained a very active Italian participation in the I. E. C. In 1923 he was elected President of the I. E. C. and served in that capacity to September 1927. He entered actively and enthusiastically into the work of the Commission and developed its activities in many new fields. During his presidency, meetings were held at The Hague, New York, and Bellagio.

When the Italian Government decided to undertake the study of a general program for the development of the telephone system, he was called upon to preside over the commission which was appointed to consider and formulate a program. The plan decided upon by this commission was adopted, and the development of the telephone system in Italy carried out in accordance with its recommendations. From 1919 to 1922 he was invited to become a Member of the Second Section of the Superior Council of the Public Works Department in Italy, which undertook a study of the problems of electric traction. His work in this council led the state railways to study the traction program from a broader point of view. During the war he was President of the Receiving Commission which had supervision over the production of shells by private industry. In the year 1922 he was elected President of the National Scientific Technical Committee and continued as its President until 1928, at which time the "Consiglio Nazionale delle Ricerche" was organized, the activities of the National Committee being absorbed by the new organization.

Doctor Semenza organized the Italian Electrical Exhibition at Marseille in 1906; he was also Commissioner General for Italy at the Exhibition of "White Coal" (energy generated by Alpine streams) and the Tourist Organization at Grenoble in 1925.

In 1921 he acted as President of the Commission sent to the United States by a group of electrical societies and financial interests to study the most recent electrical developments and to endeavor to interest American capital in Italian enterprises. He has also taken an active part in numerous international congresses, such as the First World Power Conference and la Conference des Grands Reseaux. He is Honorary President of the I. E. C., Vice-President of the International Commission on Illumination and of the Conference des Grands Reseaux, and for many years has been Honorary Secretary for Italy of the A. I. E. E. and of the I. E. E.

Doctor Semenza has published many original scientific studies, among them the extension given by him to the Kelvin Law for the calculation of conductors, graphical tables for overhead line construction, many studies on towers for transmission lines, and he was the first to propose the use of elastic supports. He has also given much study to the problems of insulation. The insulator used in the Paderno plant in 1898, which was designed by him, is considered today one of the best among pin type insulators. He also gave his active help and advice in connection with the renewal of the electrical and mechanical plants in the Scala Theatre in Milan. In 1924 he was invited to read the XV Kelvin Lecture before the I. E. E. in London.

STANDARDS

Electrical Definitions—Revised Report

Report No. 2 in the A. I. E. E. Standard's series was issued in August 1927. This report was made up of all the definitions appearing in the approved sections of the A. I. E. E. Standards of that date. It was issued to obtain criticisms and suggestions and if possible to eliminate inconsistencies. In a number of cases definitions of the same thing had developed, varying only slightly in wording. Such differences will unquestionably be necessary in some instances due to varying applications but in most cases can be eliminated through agreement of the committees having the standards affected in hand. A new report dated June 1929 is now available in which part of such coordination work has been included. The new report has also been carefully cross-indexed and brought up to date by the insertion of definitions from Standards approved since original date of publication. Copies of this new Report No. 2 may be obtained without charge by writing, H. E. Farrer, Secretary, Standards Committee, A. I. E. E., to whom all criticisms or suggestions should also be addressed.

Constant Current Transformers—A New Report

Report No. 12 on A. I. E. E. Standards for Constant Current Transformers is now available. In accordance with our regular practise with all proposed A. I. E. E. Standards this is issued with a view to obtaining the opinions, criticisms and suggestions, of as many interested persons as possible. This report was developed by a subcommittee of the Electrical Machinery Comittee of the Institute. These tentative Standards apply only to constant current transformers. Other types of transformers are covered by Section 13, "Transformers, Induction Regulators

and Reactors," and Section 14, "Instrument Transformers," both approved A. I. E. E. Standards. The new report contains definitions, rating requirements, temperature limitations and methods of making the temperature test, efficiency and losses, dielectric test, insulation resistance, lead markings for transformers, recommendations for operation. Copies of Report No. 12 can be obtained without charge by writing the Secretary of the Standards Committee at A. I. E. E. headquarters.

Switchboards and Switching Equipment for Power and Light

A Report No. 27, on proposed Standards for Switchboards and Switching Equipment for Power and Light, developed by a subcommittee of the Standards Committee, is now available for criticisms and suggestions. This report covers proposed Standards for switchboards and switching equipment not specifically covered elsewhere as apparatus. The Standards do not apply to industrial control equipment or communication switchboards and switching equipment. The following listing shows the general subjects covered in the report: Service Conditions, definitions, rating, temperature limitations, tests, name plates. Copies of this report can be obtained without charge by writing the Secretary of the Standards Committee at A. I. E. E. headquarters.

Abbreviations for Scientific and Engineering Terms

A Subcommittee on Abbreviations of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations has been working on the development of American Standards for abbreviations for scientific and engineering terms. The work of the subcommittee has now reached the point where it is possible to print their report as the proposed Tentative American Standard. The American Society of Mechanical Engineers, one of the joint sponsors with the Institute and three other groups, has issued the report in page proof form for the purpose of criticism and comment. Abbreviations of electrical terms form a part of the report. Probably the most notable feature of the proposed abbreviations is the omission of period except where the abbreviation forms a complete word, as (arm. for armature). The Sectional Committee has made the following distinction between symbols and abbreviations: A symbol is a letter or sign used in a formula as a substitute for any numerical value. A shortened expression for a name or a unit is an abbreviation and not a symbol.

The Subcommittee on Abbreviations has formulated the following fundamental rules for formation and use:

1. Abbreviations should be used sparingly in text and with regard to the context and to the training of the reader. Terms denoting units of measure are abbreviated in the text only when preceded by the amounts indicated in numerals; thus "several inches," "one inch," "12 in." In tabular matter, specifications, maps, drawings, and text for special purposes, the use of abbreviations is governed by the desirability of conserving space.
2. Do not begin a sentence with a numeral followed by an abbreviation.
3. Avoid capitals in abbreviations except in words normally capitalized.
4. Hyphenated compound words call for hyphenated abbreviations; thus "hp-hr"
5. With but few exceptions of abbreviations in common usage, the singular only is used; thus "in." for "inches," not "ins.;" but No., Nos., Fig., Figs.
6. Short words such as ton, day, and mile are spelled out.
7. Do not use abbreviations where the meaning will not be clear. In case of doubt, spell out.
8. Do not use conventional signs for abbreviations in text; thus per, not/; lb. not #; in., not ". Such signs are used sparingly in tables and similar places for conserving space.
9. The Committee endorses the movement which was begun by the International Committee on Weights and Measures in omitting the period in abbreviations of metric units and further endorses the growing tendency toward the omission in abbreviations of other origin. In the interests of economy and the elimination of waste the Sub-Committee recommends the elimination of the period in all cases except a few where such an omission results in an English word. Exceptions to this practise will be found in a few mathematical and chemical terms, such as sin, tan, log, Be, etc.
10. Do not space the letters of such abbreviations as ASME (not A S M E).
11. In text, do not use the exponents for the abbreviations of square and cube nor the negative exponents for terms involving per. The superior figures are usually not available on the keyboards of typesetting and linotype machines and composition is therefore delayed. There is also the likelihood of confusion with footnote reference numbers. These shorter forms are permissible in tables and are sometimes difficult to avoid in text.

Report of Committee of Tellers on Election of Officers

To the President
American Institute of Electrical Engineers

DEAR SIR:

This Committee has canvassed the ballots cast for the election of Institute officers for the year 1929-30, and reports as follows:

Total number of ballot envelopes received		5077
Ballots rejected, in accordance with Art. VI, Secs. 32 and 34 of the Constitution:		
From members in arrears for dues for year ending May 1, 1929	137	
Received in envelope unmarked by identifying signature	48	
Received in improper envelope	124	
Received after May 1, 1929	19	
Leaving as valid ballots		4749

These 4749 valid ballots were counted, and the result is shown as follows:

FOR PRESIDENT

Harold B. Smith	4591
Blank	158

FOR VICE-PRESIDENTS

District		
No. 2	*Middle Eastern*	
	E. C. Stone	4622
	Blank	127
No. 4	*Southern*	
	W. S. Rodman	4597
	Blank	152
No. 6	*North Central*	
	Herbert S. Evans	4595
	Blank	154
No. 8	*Pacific*	
	C. E. Fleager	4597
	Blank	152
No. 10	*Canadian*	
	C. E. Sisson	4595
	Blank	154

FOR DIRECTORS

J. E. Kearns	4656
W. S. Lee	4660
C. E. Stephens	4660
Blanks	271

For National Treasurer

George A. Hamilton	4622
Blank	127

Respectfully submitted
W. E. Coover, *Chairman*
Alek Johnson
R. R. Kime
W. C. F. Farwell per G. F. Fowler
J. T. Wells
R. A. Rich
Committee of Tellers.

Date May 14, 1929

AMERICAN ENGINEERING COUNCIL

A. E. C. APPOINTS COMMUNICATIONS COMMITTEE

To Study Couzens Bill for Regulation of the Transmission of Intelligence by Wire or Wireless

With the approval of the Executive Committee, President Berresford has announced the appointment of A. E. C.'s Committee on Communication, as follows: E. F. Wendt, Chairman; O. H. Caldwell; C. B. Hawley; Dean Dexter S. Kimball; Professor Frank A. Scott.

Shortly after the beginning of the special session of the 71st Congress, Senator Couzens introduced S. 6, April 18, 1929, which provides for the regulation of the transmission of intelligence by wire or wireless. The purpose of this bill is to regulate all forms of interstate and foreign radio transmission communications within the United States, its territories and possessions, this to be accomplished through a commission composed of five, representing five territories.

On June 4, Senator Couzens proposed an amendment to his original bill, changing the Commission's name from Commission on Communications to Commission on Communications and Power. Such a Commission would take over most of the duties of the present Federal Power Commission.

It is contemplated that the special committee of American Engineering Council on Communications will render its report prior to the meeting of the Administrative Board in October.

QUESTIONS DISCUSSED AT MEETING OF THE ADMINISTRATIVE BOARD

Among the many items handled at the meeting of the Council's Administrative Board May 24-25, in Washington, D. C., notice of which appeared in the June issue of the Journal page 484 were the Report of the Treasurer; Approval of the Revised Budget; Membership and Representation of American Society of Civil Engineers; Report of Committee on Flood Control; Appropriations for U. S. Geological Survey; Topographic Mapping; Government Reorganization; L'Enfant Memorial; Functional Outline of Work of Committee on Engineering and Allied Technical Professions; State Engineering Councils; Amendment to the Federal Constitution; Legislation Relative to Water Resources; and World Engineering Congress.

The Executive Committee recommended to the Administrative Board that Council exercise its influence to secure larger appropriations for the prosecution of the topographic mapping of the United States. This recommendation was approved by the Administrative Board.

Approximately thirty patriotic organizations have endorsed the movement to have erected here in Washington, D. C. a memorial monument to Major Charles Pierre L'Enfant. Major L'Enfant was one of the early American patriots of the Revolutionary War. He was a distinguished French engineer who offered his services and actually joined the cause of the thirteen colonists several months prior to his distinguished compatriot, Lafayette. Major L'Enfant is perhaps best known because he was commissioned by General George Washington and actually designed and laid out our National Capital City, Washington. In the proposed plans for the beautification of Washington the original designs of Major L'Enfant are to be followed in nearly all respects.

COUNCIL APPOINTS COMMITTEE ON ENGINEERING AND ALLIED TECHNICAL PROFESSIONS

The Administrative Board of American Engineering Council meeting in Washington, D. C., May 24, approved the personnel of the committee authorized by Council's Constitution. This committee is known as the Committee on Engineering and Allied Technical Professions, and will be constituted as follows: H. C. Morris, retired mining engineer of Washington, D. C., Chairman. Conrad N. Lauer, representing The American Society of Mechanical Engineers; H. A. Kidder, representing the American Institute of Electrical Engineers. (He will serve as Chairman of a similar committee for the Institute at such time as it is authorized); A. B. McDaniels, representing the American Society of Civil Engineers; and L. W. Wallace, Executive Secretary, American Engineering Council is ex-officio a member of the committee.

This Committee was formed to enable the Council to enter upon a program designed to improve the general status of the engineering profession. The program as now contemplated partakes of the following character: (1) Collect, tabulate, analyze and disseminate information concerning the earnings of engineers, such information to be so classified as to give a clear conception of the earnings of engineers in the several branches of the profession and also in various lines of endeavor such as Federal, State, and municipal employment. (2) For the purpose of suitable comparisons, information will be obtained in so far as possible relating to the earnings of other professional men. (3) To ascertain the status of the profession as measured by appropriate standards. (4) To determine the major trends of the profession. (5) To disseminate the facts ascertained. This dissemination is to be directed towards two different audiences; namely, (a) engineers; (b) the public. (6) Classification:—A determination or classification in which each type of engineer belongs, and a statement of the qualifications requisite to this classification. This is particularly needed in the Federal government service. (7) Registration of engineers:—Registration of engineers prevails in some twenty states. This movement has had no guidance on the part of any major fraction of the profession. However, because of existing registration laws no adequate plan can be projected relating to the economic and professional status of the engineer without giving due consideration to the influences and trends of registration. (8) Technical Education:—This item is listed for the purpose of raising the query as to whether or not the profession has any responsibility with reference to technical education. (9) By-Paths:—Such a broad gaged survey as is contemplated will not fail to bring to light certain corollary questions which will of necessity have to be pursued to some degree in order to get that breadth of comprehension necessary to an inclusive judgment and action. (10) Objectives for the profession:—On the basis of the information comprehended in the foregoing items, there should be an opportunity to set up certain forward looking and comprehensive objectives for the profession. Engineers are presumed to be analyzers and planners. It is therefore logical to believe that by analyzing the profession they would be able to formulate some major objectives for the profession to endeavor to realize in the years ahead. (11) Expert guidance:—It is contemplated as a result of the survey the Council will arrive at that position where it can give expert guidance to matters affecting the profession or branches thereof in local and national situations. What is contemplated here can best be illustrated by a specific example. Some months ago there arose a critical relationship between the engineers employed by the municipalities of New York and

Chicago largely relating to the salaries paid to such men. The Council hopes, as a result of the survey, to be able, when such situations arise, to send a man thoroughly versed in such matters to the locality involved for the purpose of counseling with and supplying facts to any local committee, thereby enabling such committee to be more successful in its negotiations.

MEETING OF SECRETARIES OF ENGINEERING SOCIETIES

The conference of Secretaries of Engineering Societies has been sponsored by American Engineering Council. The fourth such conference was held June 6, 1929, in Chicago.

There are many problems which all engineering societies have in common, and a meeting approximately every two years of those compelled to study and obtain some solution to these problems has been found most helpful. Among the questions discussed at the recent meeting was the standardization of forms, and procedure in effecting transfers of engineering society memberships; the matter of the adoption of standards and acceptable definitions for the designation of different grades in engineering societies was given considerable discussion.

Mr. Charles E. Billin, Secretary, Engineers Club of Philadelphia, presented an able discussion on the subject of Participation of Engineers in Civic Life of the Community.

FLOOD CONTROL OF MISSISSIPPI

Following the report of its Flood Control Committee the Administrative Board of Council, composed of Gardner S. Williams, Chairman, Baxter L. Brown, John R. Freeman, and Arthur E. Morgan, meeting in Washington, May 24, endorsed the report and recommended that a board of review consisting of non-partisan and competent civilian engineers be appointed with authority to develop the best possible solution of the Mississippi Flood Control Problem.

The Flood Control Committee represents several sections of the country and has given extensive study to the questions involved.

The Flood Control Act of 1928 provides for an expenditure in excess of $300,000,000. Many witnesses who appeared before the Flood Control Committee of the House predicted that the present plan which is being carried into execution is inadequate and may result in a disaster as great as that which occurred in 1927. In 1926 a report of the Chief of Engineers, U. S. A., stated that the valley was safe from floods.

The professional engineers through their duly constituted representatives, American Engineering Council, have continuously warned the nation of the inadequacy of the present plans for flood control on the Mississippi, and the danger involved in executing them.

Following a visit by a non-partisan delegation of the Senate and House of Representatives, Secy. of War Good has temporarily suspended action on the most controversial features of the present plan. Pres. Hoover has referred the matter to the Attorney General for a decision as to legal action permitted him as Executive of the Nation. Thus far, contracts for the proposed floodway levees in Missouri and the Boeuf Basin have not been let. It is expected that the Attorney General's decision will be that legally President Hoover is bound by the Flood Control Act of 1928 and the executive decisions of his predecessor, Mr. Coolidge, to the extent that he cannot delay or prevent the execution of the present authorized flood control plans without additional Congressional authority.

Senator Lynn Frazier of North Dakota has also introduced Senate Res. 69, the closing paragraphs of which are in part as follows:

"Resolved, That there is hereby established a board to be known as the Senate Mississippi Engineering Advisory Board, which shall be appointed, acting jointly, by the chairmen of the Committees on Commerce, Interstate Commerce, and Agriculture and Forestry; said chairmen shall have the authority to fix the compensation of the members of said board and to remove or replace at any time a member thereof. The said board shall submit a report to each of the said committees, and each committee shall transmit to the Senate the said report with their findings thereon.

"The said board shall be composed of eleven members who shall be nominated as follows: One, a financial economist, by the President of the Senate; two Army engineers by the chairman of the Committee on Interstate Commerce; two civilian engineers by the chairman of the Committee on Agriculture and Forestry; two civilian engineers by the American Society of Civil Engineers; and two civilian engineers by the American Society of Mechanical Engineers.

"The eleven members shall be qualified as follows: One member shall be an expert financial economist; two shall be Army engineers; and eight, each of whom shall be a distinguished civilian engineer of great attainment and experience, to be selected from as many of the following engineering classifications as practicable: Civil, mechanical, electrical, contracting, structural concrete, foundation, locks, dams, dredging, hydraulic, or marine construction.

One of the proposals which any review board studying the Mississippi Flood Control Problem would be expected to investigate, is the so-called "Riker spillway project," illustrated model of which is now on display in the basement of the Senate Office Building.

CENSUS BILL TO PASS

The Constitution of the United States requires a census every ten years for the purpose of re-apportioning the membership of the House of Representatives. Although the census has been taken every ten years, the House of Representatives was not re-apportioned after the 1920 census. The technical and political reasons assigned for the failure of Congress to comply with this Constitutional requirement are numerous, but the outstanding fact seems to be that in the last twenty years the large cities and industrial centers have gained very rapidly in population, while the rural sections of the country have gained only slightly. Many of the Members of Congress from states thus adversely affected by a reapportionment have opposed and thus far prevented a reapportionment being made.

According to the present legislation, the fifteenth and subsequent censuses will be restricted to population, agriculture, irrigation, drainage, distribution, unemployment, and mines, all subjects of vital concern to the engineering profession.

Among the chief differences in the bills as passed by the two Houses were the following: The Senate provided for a census of radio sets. The House struck out this provision. In conference the Senate accepted the amendment.

One of the most constructive features of the present census bill is the provision for the reapportionment of the House of Representatives automatically in accordance with the method used in the last preceding apportionment, leaving the total membership of the House of Representatives at its present figure of 435 members. The President is also instructed by this measure to report to Congress the apportionment that would result by the method used in the last preceding apportionment by the method known "as the method of major fractions," and by the method known as "the method of equal proportions."

The bill also provides that if the Congress to which the President's statement is transmitted fails to pass a reapportionment law, then each state shall be entitled to the number of representatives shown in the statement, based on the method used in the last apportionment until an apportionment law is enacted.

Professional and technical men familiar with the Constitution will view with regret the fact that Congress has not seen fit to adopt the scientifically correct and mathematically demonstrated method of reapportionment known as "equal proportions." For political reasons it was not possible to secure the enactment requiring the use of this method.

The administration and execution of the coming census will be under the Director of the Bureau of Census, Dr. William M. Steuart. His assistant is Dr. Joseph A. Hill. The heads of the various departments are as follows:

Population, Leon E. Truesdell: *Agriculture, Cotton and Tobacco*, William L. Austin: *Manufactures*, LaVerne Beales: *Financial Statistics of States and Cities*, Starke M. Grogan: *Vital Statistics*, Doctor T. E. Murphy: *Tabulation*, William B. Cragg; and *Geographer*, Clarence E. Batschelet.

Discussion at Dallas Regional Meeting

A summarized report of the discussion at the technical sessions of the Dallas Regional Meeting held May 7-9 is given in the following paragraphs.

A complete record of the discussions will be published with the respective papers in the TRANSACTIONS.

A report on other features of this meeting was published in the June issue of the JOURNAL.

POWER SESSION

Developments in Network Systems and Equipment, T. J. Brosnan and Ralph Kelly.

Standard-Voltage A-C. Network, John Oram.

Automatic Reclosing of High-Voltage Circuits, E. W. Robinson and S. J. Spurgeon.

In discussing the first two papers F. E. Johnson emphasized the difficulty of selecting proper fuses for networks. He advocated that the fuse should be of such size that it will give relief on primary cable faults rather than secondary cable faults.

R. J. Wensley, speaking on the last paper, pointed out that automatic reclosing equipment was in use as early as 1916. He mentioned that the advantages of simple d-c. closing solenoids may be enjoyed where only a-c. supply is available by employing small copper-oxide rectifiers to give the direct current.

SECOND TECHNICAL SESSION

Bare-Wire Overhead Distribution Practise, M. C. Miller.

Interconnection in the Southwest, G. A. Mills.

Electrification of Oil Pipe Lines in the Southwest, D. H. Levy.

Selective Remote Metering Equipment, R. J. Wensley.

In connection with Mr. Miller's paper, G. A. Mills stated that his company prefers to use weatherproof wire for the mechanical separation which it affords. He stated that his company is experimenting with a lead oxide coating over the weatherproof insulation, which coating has been proposed as a protection against deterioration of the insulation. J. B. Thomas stated that his company has had four year's experience with bare wire and that both installation and maintenance costs are lower than with weatherproof wire.

Commenting on Mr. Mills' paper, R. J. Wensley enumerated some of the engineering problems that arise on interconnected systems, such as voltage control in transformers, stability, quick excitation, relaying and communication.

In answer to questions regarding the use of synchronous and wound-rotor induction motors in oil pip-line pumping, D. H. Levy pointed out an important disadvantage of these two motors; namely, that they have brushes which may spark and cause explosions of the oil vapor which is often present. Enclosure of the motor in a separate room has several disadvantages he said.

THIRD TECHNICAL SESSION

Progress in Lightning Research, F. W. Peek, Jr.

Lightning Studies of Transformers by the Cathode Ray Oscillograph, F. F. Brand and K. K. Palueff.

Flying-Field and Airway Lighting, H. R. Ogden.

Electrical Features of the New Kansas City Water Works Plant, A. L. Maillard.

J. F. Peters, in discussing the second paper of this session, stated that the physical proportions of a transformer winding have very much to do with the voltage distribution and that with windings of the correct proportions the voltage distribution is uniform for the impulses which might produce dangerous oscillation.

There was further discussion by D. W. Roper, Edward Beck, and J. H. Cox on the work now being done to determine the nature of the surges caused by lightning on transmission and distribution lines.

FOURTH TECHNICAL SESSION

Meeting Long Distance Telephone Problems in the Southwest, H. R. Fritz and H. P. Lawther.

Railway Train Signal Practise, P. M. Gault.

Telephone Transmission Networks, T. E. Shea and C. E. Lane.

Program Transmission over Telephone Circuits for National Broadcasting, F. A. Cowan.

In answer to questions on his paper Mr. Gault stated that semaphore signals are becoming obsolete on many railroads. The first cost and maintenance expense he said are higher for the semaphore than for the light signals.

In discussing the telephone papers F. A. Cowan brought up the point of resistance noise in communication circuits which is caused by the thermal agitation of electrons within a conductor. This resistance noise he said has to be considered as its level must not be so high as to interfere with the signal. Other facts in connection with the history and the extent of communication systems were discussed by S. P. Grace, J. W. Creasy, C. W. Mier, E. T. Mahood, W. O. Pennell, and A. B. Covey.

Muscle Shoals Again Before Congress

On May 28, Senator Norris of Nebraska introduced S. J. Res. 49 which provides for the operation of Muscle Shoals, for the experimental production of nitrogen and for the sale of surplus power there generated. The following day, the Senate Committee on Agriculture and Forestry, by vote of 13 to 0, ordered a favorable report on this legislation.

This action was taken after Senator Norris had explained that the resolution is practically identical with the joint legislation passed by both Houses during the last Congress and which was pocket-vetoed by President Coolidge.

An appropriation of $10,000,000 would be authorized by this resolution to start operations, and expenses thereafter would be met by revenues derived from surplus power.

Award of George Montefiore Levi Foundation

The Jury of the first triennial meeting of the FOUNDATION GEORGE MONTEFIORE LEVI held at Liege September 21, 1911, has awarded to Mr. Bela Gati, Chief Engineer of Telegraphs, Budapest, a prize of three thousand francs, for his memoirs entitled:

a. Researches on the Microphone and on the Telephone at Many Thousand Kilometers Distance; and

b. Telephone Relays.

The Jury is composed of: Mr. Eric Gerard, President, Messrs. Banneux, Boucherot, Count Cicogna, de Bast, Kapp, Kennelly, Kittler, Libert and Roosen, members; Mr. L'Hoest, Secretary General.

Mr. Bela Gati was elected an Associate of the Institute in 1925.

PERSONAL MENTION

W. J. MOULTON-REDWOOD, previously Plant Engineer for the General Motors New Zealand Ltd. is now with The Canadian National Railways in the capacity of Engineer Computor in the Valuation Department.

E. FINLEY CARTER has resigned from the General Electric Company, Schenectady, where he was employed in the Radio Engineering Department in charge of special developments, to direct radio frequency developments for the Mutual Research Corporation, located at Long Island City.

O. H. ESCHHOLZ has been appointed manager of the Patent Department of the Westinghouse Electric and Manufacturing Company, succeeding O. S. Schairer, who resigned to accept a similar position with the Radio Corporation of America. Mr. Eschholz's headquarters will be at the company's East Pittsburgh works.

O. G. CORDES has recently severed his connections with the

Castanea Paper Company, and New York and Pennsylvania Company, where he was employed as Research Engineer, to become General Industrial Engineer for the Engineering Division of the Westinghouse Electric and Manufacturing Company's Middle Atlantic District, Philadelphia, Pa.

HADLEY F. FREEMAN, of Smith and Freeman, patent attorneys, 1310 Hanna Building, Cleveland, Ohio, has opened a branch office at 907 Otis Building, Chicago, under the name of Freeman and Sweet. Mr. Freeman will act as counsel for the Chicago office and conduct its litigation, but will remain resident here, and the Chicago office will be in charge of Mr. Sweet.

MORTIMER SILVERMAN, of Brookline, assistant to the president of the Boston and Maine Railroad, has resigned to become Chief Engineer and Assistant to the President of the United Merchants' and Manufacturers' Corp., and in his new position will again be associated with Homer Loring, former Chairman of the Boston and Maine with whom he was formerly connected for 17 years.

D. MCFARLAN MOORE, Fellow of the A. I. E. E. and Past Vice-President of the Illuminating Engineering Society well known as one of the earliest pioneers in gaseous conduction, and inventor of the television lamp, has been elected a member of the Lehigh Chapter of the Society of the Sigma XI.

Mr. Moore also recently addressed the Electrochemical Department of Columbia University.

ARTHUR W. GRAY, by whom the Thermal Expansion Laboratory of the Bureau of Standards was established and who originated important methods and apparatus that are still in use there, has joined the staff of The Brown Instrument Company as Associate Director of Research, where he will be engaged mainly in the development of scientific and industrial instruments. For this work Dr. Gray is well fitted by his long training and experience.

PARKER HAYWARD DAGGETT, formerly Professor of Electrical Engineering at the University of North Carolina has been elected Dean of the College of Engineering, Rutgers University, New Jersey. Professor Daggett has been President of the North Carolina Society of Engineers, and was active in preliminary plans for the North Carolina Section of the A. I. E. E. which was organized May 2, 1929, in accordance with authority granted by the Board of Directors on March 21.

H. SPEIGHT of the Westinghouse Electric and Manufacturing Company has been appointed to the office of Section Engineer in charge of electrochemical and electrometallurgical work in the company's General Engineering Department, East Pittsburgh, Penn., effective May 1, 1929. Following his experience in the public utility field, Mr. Speight for two and one-half years was manager of an electrical contracting company in Liverpool.

FRANK A. MERRICK, an executive of the electrical industry who has served in the United States, Canada, and Great Britain, was recently elected President of the Westinghouse Electric and Manufacturing Company. He succeeds E. M. Herr, President since 1911, whose resignation was tendered that he might go on an extended vacation necessitated by his present state of health.

Mr. Merrick advances to president from the position of vice-president and general manager. He joined the Institute as an Associate in 1907.

JOHN F. PETERS, prominent consulting engineer of the Westinghouse Electric and Manufacturing Company, was awarded the Longstreth Medal for the invention of the klydonograph—the only simple device in the world for recording the effect of lightning as it strikes a transmission line. The award was made on May 15 at the Medal Meeting of the Franklin Institute in Philadelphia. In 1925 Mr. Peters was appointed to his present position of Consulting Engineer for the entire Westinghouse organization. Today he is credited over 30 patented inventions.

LEWIS TAYLOR ROBINSON, Engineer-in-Charge of the General Engineering Laboratory of the General Electric Company, Schenectady, a Fellow of the Institute since 1912 and twice one of its Vice-Presidents, was the recipient of the honorary degree of Doctor of Science at the 133d Annual Commencement of Union College, Schenectady, June 1929. In conferring the degree, Doctor F. P. Day said of Mr. Robinson, "Lewis Taylor Robinson, inventor, engineer, musician, has for many years occupied a leading position in the world of electrical science. He has contributed materially to the progress of the art through many valuable inventions and papers before learned societies, giving unselfishly of time and energy as a member of many scientific national and international committees; a student in the truest sense of the word." Under his administration, the Laboratory has established and maintained a complete set of electrical standards for the Company beside his contributions of many important machines and devices, notable among which are the oscillograph, means for determining the magnetic properties of iron, mercury arc rectifier developments and recently a system of the motion pictures with sound. During 1919-1920 he was Chairman of the Institute's Standards Committee. He is also active on the Board of Trustees of the United Engineering Societies and was one of the Institutes representatives on the Joint Conference Committee which was responsible for the founding of the present American Engineering Council. He is a member of the U. S. National Committee of the International Electrotechnical Commission, of the Committee on Insulation of the National Research Council, the Society for the Promotion of Engineering Education, the American Association for the Advancement of Science, the N. E L. A., N. E. M. A., the Society of Engineers of Eastern New York, and the American Society of Motion Picture Engineers. He is also a Fellow of the American Physical Society. Many men now in the employ of the General Electric Company as well as in other companies served their apprenticeships with Dr. Robinson and it may be accurately said that his influence has abundantly permeated the electrical industry.

Obituary

Ralph L. Werden, of the Long Lines Engineering Department of the American Telephone and Telegraph Company, New York, and a Member of the Institute since 1918, died at Bogota, March 21, 1929, after a two-day illness of influenza and bronchial pneumonia. Mr. Werden was active in the work of the telephone line connecting New York and San Francisco; he was a trustee of the William F. Burk Lodge No. 230 and of the Bogota Masonic club. He also served on the general board of assessment commissioners.

Charles Francis Brush, inventor of the arc light, an outstanding scientist, humanitarian, philanthropist and one of the Institute's first Managers, 1884-1887, died at his home in Cleveland, Ohio, June 15, 1929 at the age of eighty, complications from bronchitis which developed into pneumonia causing his death.

Mr. Brush was born at Euclid, Ohio, March 17, 1849, both of his parents coming from old American families. His grammar and high school education was obtained in the public schools of Cleveland from which he was graduated at an early age. While still at school, he became intently interested in electrical apparatus and, in true boy fashion, experimented with his own construction of static machines, induction coils, and small motors; his graduating essay, in fact, was on the dynamo and arc light, based upon the Wilde experiments in London. In 1869 he was graduated in mining engineering from the University of Michigan, returning for a postgraduate course which won for him his M. S. degree, followed by a Ph. D. from the Western Reserve University. This latter university also conferred upon him an honorary degree of LL. D., as did also the Kenyon College in 1903.

It was in 1860 that the Italian, Paccinotti, made a great discovery in electricity, but it was destined to remain buried in the archives of Italian libraries until a young Belgian by the name of Gramme reinvented the dynamo electric machine.

Doctor Brush, then a young man just out of college, was one of the first to realize the value of this "nucleus" and to undertake further the history of its evolution and application with variation and improvement. By 1876 he had designed a dynamo—constructed under his own supervision—a pioneer machine to be exhibited at the Paris Exposition in the United States Historical Exhibit. In 1877 he introduced the compound field winding for constant potentials now so generally applied to electric lighting; its first use was in connection with plating machines. At the Charitable Mechanics' Fair in Boston, (1878), an exhibit of greatest historic and scientific interest, was displayed the earliest form of what afterward became the world-famous Brush arc light machine. His, too, was the great invention of the differential arc lamp, the construction and operation of which included the principle making it possible to operate lamps in series instead of in parallel. Another apparatus of great significance,—the automatic cut-out, permitting each lamp to cut itself out of circuit should trouble arise or the carbon burn out was of his development. This was looked upon as one of the greatest inventions of the era—a fact conceded by even Doctor Brush's contemporaries in the same field of development.

From that time on it was a rapidly growing industry. Copper plating of carbon electrodes was also introduced by Doctor Brush and yielded large royalties. In 1881 the Brush Electric Company was incorporated and capitalized at $3,000,000. Approximately ten years later when the General Electric Company was formed, it absorbed this company and the works were removed from Cleveland to Schenectady, but in the meantime, through the formation of other corporations, the Brush apparatus and system were being introduced. The storage battery problem received considerable attention from Doctor Brush, and as a result of his effort, great improvement was accomplished in the manufacture of lead plates. He too devised the ingenious system of charging storage batteries from an arc light system and the subsequent subdivision of light, demonstrating that it was possible to run incandescent lights on an arc light circuit.

In 1881 at the International Electrical Exposition in Paris there was exhibited by the English Brush Company as one of the most interesting features, a certain Brush apparatus. It was in this year too, that Doctor Brush was decorated by the French Government as Chevalier of the Legion of Honor; in 1889, the American Academy of Arts and Sciences awarded to him the Rumford medal, bestowed by both the Royal Society and the American Academy of Arts and Science, "for the most important discovery or useful improvement on heat and light." Doctor Brush is a corporator of the Case School of Applied Science, trustee of the Western Reserve University, Fellow of the American Academy of Arts and Sciences; member of the Physical Society, the American Philosophical Society; Fellow of the American Association for the Advancement of Science; Life Member of the British Association, Ohio State Board of Commerce, Cleveland Chamber of Commerce (of which he was also President 1909-10); The American Society of Mechanical Engineers; members of the Archeological Institute of America, the American History Association, the National Electric Light Association, the Franklin Institute, the American Chemical Society, the Royal Society of Arts; Fellow of the American Geographic Society and the N. British Academy of Arts. He was a Charter Member of the Institute and in 1913 received the Edison Medal award.

A. I. E. E. Section Activities

NEW YORK SECTION

Second Power Group Meeting. On the evening of Tuesday, May 28th, the Power Group of the New York Section held its second meeting. Through the courtesy of the New York Edison Company, the auditorium of the Consolidated Gas Building was made available, and the meeting called to order by Chairman George Sutherland at 7:45 p. m. A motion picture on the "Construction of the Conowingo Hydroelectric Development" was shown followed by the two papers: *The Economical Division of Generating Means*, by James D. Winans and F. W. Gay of the Public Service Production Co., and *Experience with the Rocky River Hydroelectric Development*, by E. J. Amberg of the Connecticut Light and Power Co. The first paper discussed from an economic standpoint the use of artificial water power (pump storage) and gasoline engines as a peak-load installation. The second paper was a discription of the only large pumped storage reservoir in this country, with operating experiences. General discussion followed. Attendance was about 125.

ANNUAL STUDENT PROGRAM OF PORTLAND SECTION

The annual joint meeting of the Portland Section and the Oregon State College Branch was held at the College on May 25, 1929, with an attendance of 170. The following program was presented by students:

The Neon Stroboscope, Artro Swingle and V. E. Kerley.

The Photoelectric Cell and Its Application to the Measurement of Illumination, R. W. Mize and Zed Atlee.

Characteristics of Bakelite Dielectric at Radio Frequencies, S. C. Bates and Fred M. Burelback.

Static Electricity in the Printing Industry, R. F. Williams.

Short-Time Fusion Characteristics of Copper Conductors, S. O. Rice.

The names of the officers of the Section for 1929-30 were announced as follows: Chairman, H. H. Cake, Pacific States Electric Co.; Secretary-Treasurer, A. H. Kreul, Portland Electric Power Co.; Executive Committee, L. W. Going, Chief, City Inspection Bureau, R. J. Davidson, Pacific Power & Light Co.

COMPETITION HELD BY SEATTLE SECTION

At a meeting held on May 21, 1929, the Seattle Section offered a cash prize of $25.00 for the best paper presented by one of its members who had never presented a paper at a Section meeting. The program was as follows:

Radio Interference from Suspension Insulators, E. L. White, Communication Engineer, Puget Sound Power and Light Co.

Kilovolt-Ampere-Hour Meters, Prof. G. R. Shuck, University of Washington.

Balanced and Directional Ground Relay Protection on Parallel Lines, T. T. Smith, Puget Sound Power and Light Co.

Operation of a Specific Interconnection, A. W. Mathis, Chief Load Dispatcher, Puget Sound Power and Light Co.

The prize was awarded to Professor G. R. Shuck. All the papers were considered of high quality.

Reports of several Section committees were presented, and the following officers were elected to take office August 1, 1929: Chairman, Dr. L. N. Robinson; Secretary-Treasurer, Prof. George S. Smith. The attendance was 82.

PAST SECTION MEETINGS

Akron

Joint meeting with Municipal University of Akron Branch. (Complete report on pp. 492-3 of June JOURNAL.) April 25.

Demonstration at the High-Voltage Laboratory of the Ohio Insulator Company, Barberton. Buffet luncheon was served by the Company and a brief talk was given by A. O. Austin, Chief Engr. May 10. Attendance 420.

Boston

Dinner meeting. The following officers were elected for next year: Chairman, W. H. Colburn; Vice-Chairman, J. P. Kobrock; Secretary-Treasurer, G. J. Crowdes; Members of Executive Committee: C. A. Corney, E. W. Dillard, R. W. Adams; Representative to The Affiliated Technical Societies of Boston, J. W. Kidder. Entertainment with C. C. Pierce as toastmaster. May 16. Attendance 200.

Cincinnati

Student program. (See report in Student Activities dept.) May 16. Attendance 35.

Cleveland

Talk by R. F. Schuchardt, President, A. I. E. E., on *Winning the World*, in which he urged engineers to cooperate with the city on great civic projects. Prof. H. B. Dates, Counselor, Case School of Applied Science Branch, spoke on the cooperation of the Student Branches with the Sections. Committee reports. The following officers were elected for next year: Chairman, Prof. T. D. Owens; Secretary-Treasurer, Wm. H. LaMond; Chairman, Meetings and Papers Committee, F. W. Braund; Members of Executive Committee, P. D. Manbeck, H. L. Martien, and F. R. Winders. Dinner preceded the meeting. May 23. Attendance 101.

Columbus

Joint meeting with Ohio State University Branch. (Report on p. 492, June JOURNAL.) May 3. Attendance 40.

Dallas

The Laying of a New Armored Telephone Toll Cable, by G. A. Dyer, Plant Engr., Southwestern Bell Tel. Co. Motion pictures.

Construction Methods Used in Erecting a Transmission Line Across Desert Country, by J. B. Thomas, Chief Engr., Texas Power & Lt. Co. Illustrated. A report on the Dallas Regional Meeting was given. Result of recent election of officers to take office August 1 reported as follows: Chairman, J. B. Thomas; Secretary, A. Chetham-Strode; Chairman, Meetings and Papers Committee, D. H. Levy; Chairman, Entertainment Committee, C. G. Matthews; Chairman, Membership Committee, F. A. Cooper. May 22. Attendance 54.

Denver

Ladies' Party. Program in charge of Mrs. W. H. Bullock. Dinner, musical entertainment, and card party. May 16. Attendance 60.

Annual Meeting, held at University of Colorado. Address by F. W. Bradley, President, A. I. M. E. The Secretary presented the annual report. The following officers were elected for the year commencing August 1, 1929: Chairman, W. H. Bullock; Vice-Chairman, R. B. Bonney; Secretary-Treasurer, N. R. Love. May 23. Attendance 700.

Fort Wayne

Sixth Annual Banquet and Ladies' Night.

Astronomy, by Prof. Gingery, Principal, George Washington High School, Indianapolis. A report on the activities of the Section was given by the Secretary-Treasurer. Prof. W. T. Ryan, Vice-President, Great Lakes District, A. I. E. E gave a brief talk. The names of officers chosen in the recent election to take office August 1 were announced as follows: Chairman, F. W. Merrill; Vice-Chairman, J. F. Eitman; Secretary-Treasurer, E. J. Schaefer; Assistant Secretary-Treasurer, F. W. Winje; Executive Committee, A. L. Hadley, M. J. Payton. May 16. Attendance 58.

Houston

Automatic Traffic Control, by H. B. Cammack, Houston Electric Co. Officers of the Section elected for next year: Chairman, L. K. Del Homme; Secretary-Treasurer, C. D. Farman. Dinner meeting. May 22. Attendance 32.

Indianapolis-Lafayette

Talking Movies, a Development of the Telephone, by P. L. Thompson, Western Elec. Co., with demonstration of equipment and several reels of talking pictures. The Chairman reported results of election of officers for coming year. Joint meeting with A. S. M. E. Section. May 28. Attendance 275.

Kansas City

132,000-Volt Cables, by W. S. Clark, Engineer-in-Charge, Cable Dept., General Elec. Co. Slides. Several members reported on the Dallas Regional Meeting. Election of officers for next year as follows: Chairman, A. B. Covey; Secretary-Treasurer, J. S. Palmer. May 20. Attendance 63.

Los Angeles

Science and Research in Telephone Development, by S. P. Grace, Ass't. Vice-President, Bell Telephone Laboratories, Inc. The Executive Committee entertained Mr. Grace at dinner. Chairman Caldwell announced the results of the recent election as follows: Chairman, N. B. Hinson, Secretary, H. W. Hitchcock; Assistant Secretary, P. S. Biegler; Executive Committee, F. E. Dellinger, C. E. Johnson, A. P. Hill and F. W. Maxstadt. May 14. Attendance 2250.

Louisville

The Engineer and the Modern Community, by J. P. Barnes, President, Louisville Railway Co. Committee reports. Election of officers for next year: Chairman, H. W. Wischmeyer; Secretary-Treasurer, P. P. Ash; Executive Committee, R. E. Tafel, T. B. Carter, S. T. Fife, and E. D. Wood. May 31. Attendance 24.

Lynn

The Experiences of a Newspaper Photographer, by A. H. Blackington. Illustrated lecture. Ladies' Night. May 7. Attendance 350.

Lecture by Dr. G. H. Bigelow, Massachusetts Commissioner of Public Health. Dr. Williams, U. S. Public Health Commission spoke on mosquitoes and methods of destroying them. The following officers were elected for next year: Chairman, I. F. Kinnard; Vice-Chairman, A. L. Ellis; Secretary-Treasurer, H. K. Nock; Assistant Secretary, W. K. Dickinson; Chairman, Membership Committee, L. E. Hildebrand; Chairman, Entertainment Committee, W. C. Harris; Chairman, Local Convention Committee, Dr. S. A. Moss; Chairman, Trip Committee, M. S. Wilson; Chairman, Publicity Committee, R. D. Amsden; Local Member, Executive Committee, H. A. Rising. Refreshments served. May 16. Attendance 50.

Madison

Slides describing "Kinematographic Studies in Aerodynamics." Baron Shiba high-speed motion pictures, and film "The Flight of Birds." The retiring Chairman, Prof. L. J. Peter urged that a few of the programs next year be made up from local talent together with round table discussions of engineering problems. Several excellent suggestions were given by the Section members for future meetings. Committee reports presented. May 22. Attendance 100.

Mexico

Lecture by A. F. Martinez, Asst. Engr., Distribution Dept., Mexican Lt. & Pr. Co., on methods of calculation for the proper location of trolley wire in curves and suggestions for the procedure to be followed during installation. April 16. Attendance 16.

Lecture by B. M. Antipovitch, Asst. Engr., Elec'l Dept., Mexican Lt. & Pr. Co., on operating characteristics of radio apparatus. May 14. Attendance 15.

Milwaukee

Some Examples of the Use of Electricity for Measuring Non-Electrical Quantities, by Arthur Simon, Cutler-Hammer Mfg. Co.;

Electrical Measuring and Control for Economical Production of Gas, by C. S. Pinkerton, and

Automatic Mixing of Gases, by E. Schmidt. April 3. Attendance 70.

Minnesota

Meeting held to stimulate interest in the World Engineering Congress to be held in Tokio, Japan, in November. Motion picture film on important engineering projects in Japan, with introductory talk by Max Toltz. A travelogue showing a trip through the Orient was presented by Victor Bloom, a world traveler with the American Express Company, with lantern slides. Joint meeting with Sections of A. S. C. E, A. S. M. E., Minneapolis Engineers Club, St. Paul Engineers Society and A. I. E. E. Branch. May 6. Attendance 60.

Niagara Frontier

Charles R. Huntley Station: Turbo-Generators, Auxiliaries, and Controls, by E. P. Harder, Engg. Dept., Buffalo General Electric Co., and

Powdered Fuel Boilers, by H. M. Cushing, Chief Engr., Buffalo General Electric Co. Dinner preceded the meeting. April 19. Attendance 100.

Oklahoma

Joint meeting with Student Branches (See report in Student Activities dept.). May 24. Attendance 35.

Philadelphia

Electricity and Chemistry, Teammates in Progress, by Dr. H. E. Howe, Editor, Industrial & Engg. Chemistry. Dinner preceded the meeting. May 13. Attendance 60.

Pittsburgh

Miracles of Science, by H. C. White, Edison Lamp Works, General Electric Co. Election of officers for next year. Annual dinner meeting. Ladies were invited. May 21. Attendance 700.

Portland

Science and Research in Telephone Development, by S. P. Grace, Asst. Vice-President, Bell Telephone Laboratories, Inc. May 28. Attendance 2400.

St. Louis

Meeting Long Distance Telephone Problems, by John Casey, Transmission Engr., Southwestern Bell Tel. Co. (Prepared by H. R. Fritz, Transmission and Protection Engr. of the same company). Attendance prizes awarded to J. N. Embree, J. B. Baltzer, Ned Crider, L. O. Campbell, G. H. Quermann, C. P. Potter, and H. P. Strieder. May 15. Attendance 43.

Saskatchewan

Joint dinner meeting with Regina District Amateur Radio Club. Radio Communication in the North West Territory, by Capt. H. A. Young, R. C. C. S. March 8. Attendance 30.

Joint dinner meeting with Regina District Amateur Radio Club. *The Nature of Electrical Conduction through Metals*, by Dr. Thomas Alty, Professor of Physics, Saskatchewan University. April 12. Attendance 36.

Seattle

Science and Research in Telephone Development, by S. P. Grace, Asst. Vice-President, Bell Tel. Laboratories, Inc. June 4. Attendance 2040.

Sharon

The Latest Developments in Electrical Engineering, by W. D. Shirk, Westinghouse Electric & Mfg. Co.;

The Aston Process for Making Wrought Iron, by Dr. Jas. Aston, and

The Latest Developments in Central Stations, by C. S. McCalla. Joint dinner meeting, Youngstown, with Youngstown Branch, Iron & Steel Electrical Engrs. May 11. Attendance 150.

Communism, by Capt. J. R. O'Brien, under the auspices of the Constitutional Educational League of America. Prof. J. L. Beaver, Vice-President, District No. 2, gave a brief talk, in addition to a short talk by J. S. Hebrew, Westinghouse Elec. & Mfg. Co. Annual Banquet, H. L. Cole, toastmaster. June 4. Attendance 197.

Springfield

Illuminating Engineering with Special Reference to Spectacular Effects, by W. D. Ryan, Director of the Illuminating Laboratory, General Electric Co. Slides. Annual Ladies' Night. April 22. Attendance 250.

Discussion of proposed changes in Institute publications as outlined in circular letter of W. S. Gorsuch, Chairman, Publication Committee. May 20. Attendance 25.

Toronto

The Value of a Museum to Industry and the Home, by Dr. E. T. Currelly, Curator, Royal Ontario Museum. Chairman E. M. Wood, reported upon the past year's activities. Reports were given by the Secretary and by the Chairman of the Meetings and Papers Committee of the Section. A. B. Cooper, Vice-President, District No. 10, presented the Regional Prize for Initial Paper to H. R. Sills, Canadian General Electric Co. Chairman Wood presented the Toronto Section prize of $20.00 to R. E. Jones for the best paper given before the Toronto Section. Following officers elected for next year: Chairman, F. F. Ambuhl; Secretary, W. F. Sutherland; Executive Committee, A. D. Bradt, J. Chipperfield, T. W. Eadie, G. D. Floyd, D. A. MacKenzie and Jos. Showalter. May 10. Attendance 62.

Urbana

Election of officers for next year: Chairman, M. A. Faucett; Secretary, C. E. Skroder. May 21. Attendance 20.

Utah

Dance, May 24. Attendance 100.

Vancouver

Reports of officers and committees. The Regional First Prize for District No. 10 for 1928 was presented to H. M. Lloyd for his paper entitled "Railway Motors." Following officers elected for next year: Chairman, J. Teasdale, British Columbia Electric Railway Co.; Executive Committee, C. W. Colvin, G. R. Wright, and H. Vickers. General discussion of ways and means of increasing Section's attractiveness and value to members. June 4. Attendance 31.

Washington

Mercury Arc Rectifiers, by F. A. Faron, Railway Dept., General Electric Co. Dinner in honor of the speaker preceded the meeting. Election of officers to take office August 1. Light refreshments. May 14. Attendance 120.

Worcester

Inspection of the electrically operated billet mill and continuous rod mill at the South Works of the American Steel & Wire Co. Election of officers for the year 1929-30. Business meeting was followed by motion pictures of the manufacture of paper insulated power cable. June 5. Attendance 32.

A. I. E. E. Student Activities

STUDENT PROGRAM IN CINCINNATI

At a joint meeting of the Cincinnati Section and the University of Cincinnati Branch held at the University on May 16, 1929, the principal parts of the program were supplied by graduate students as indicated below:

J. E. Middleton, atomic hydrogen welding; C. D. Clark, subscriber telephone circuits; Wm. Kutcher, electrolytic condensers; R. P. Glover, radio broadcast receivers; J. J. O'Callaghan, commercial frequency meters for radio work; C. D. Coy, electromagnetic sound systems; R. E. Colado, d-c. street railway feeder protection; W. P. Fegley, bi-metallic thermostats.

The attendance was 35.

JOINT MEETING OF OKLAHOMA SECTION AND NEIGHBORING BRANCHES

The Oklahoma Section and the University of Oklahoma and Oklahoma A. & M. College Branches held their annual joint meeting at Stillwater on May 24, 1929. The following program was presented by students and professors:

A Survey of Oil Field Electrification in Oklahoma, Prof. R. E. Willey, Oklahoma A. & M. College.

The Condenser Type Single-Phase Motor, Prof. B. A. Fisher, Oklahoma A. & M. College.

Design of Direct-Current Calculating Table, Richard Mason and Byron J. Cook, University of Oklahoma.

The Relation between the Gain in Egg Production by Artificial Methods and Per cent Sunshine, G. T. Isbell, Oklahoma A. & M. College.

Thermal Characteristics of Underground Cable Ducts, Ralph W. Coursey, University of Oklahoma.

Thermal Characteristics of Underground Transformer Vaults, Roy L. Jones, University of Oklahoma.

Interference Elimination by Use of Vacuum Tube Bridge, J. E. Peek, Oklahoma A. & M. College.

Radio Flying Aids with Special Reference to the Absolute Altimeter, E. P. Shultz and Wm. A. Woods, University of Oklahoma.

Some Examples in the Determination of Empirical Equations, Kenton D. McMahan, Oklahoma A. & M. College.

Piezo electric Crystal-Controlled Oscillators, LeRoy Moffett, Jr., University of Oklahoma.

A first prize of $15.00 and a second prize of $10.00 were awarded to K. D. McMahan and Roy L. Jones, respectively.

After the completion of the program, a luncheon was held in the College cafeteria, and in the afternoon the faculty members escorted the visitors through the buildings. The attendance was 35.

STUDENT BRANCH ORGANIZED AT NORTH DAKOTA

At the meeting of the Board of Directors held on May 22, 1929, authority was granted for the formation of a Student Branch of the Institute at the North Dakota Agricultural College. This Branch has been organized and the following officers were elected: Chairman, J. C. Langaunet; Vice-Chairman, Lewis Nelson; Secretary-Treasurer, R. W. Scott.

BRANCH MEETINGS

University of Arizona

Motion picture, "Electrical Measuring Instruments." April 10. Attendance 16.

Storage Batteries, by Carl Gieringer, student;

Lightning Phenomena, by Frank Henderson, student, and

Estimating and Drafting for Electrical Work with the Southern Pacific Railroad, by Barney Shehane, student. April 17. Attendance 18.

Television, by O. K. Mangum, student, and

Electric Elevators, by Fred Denny, student. April 24. Attendance 20.

Remote Control of Torpedoes, by George Walton, student, and

Hydrogen Cooling of Electrical Machinery, by Roy Goar, student. May 1. Attendance 14.

Tidal Power, by C. A. Macris, student, and

Charging Equipment for Electric Automobiles, by John McBride, student. May 8. Attendance 13.

Voltage Standardization, by Harold Soliday, student. Following officers elected to take office immediately: President, Barney Shehane; Vice-President, Roy Goar; Treasurer, G. W. Walton; Secretary, F. F. Denny. May 15. Attendance 17.

Niagara Falls, by Wm. Tremaine, student, and

Tucson Gas and Electric Company, by Max Pooler, President, Tucson Public Utilities Corp. Dinner preceded the meeting May 22. Attendance 24.

Turbine Electric Propulsion of Ships, by O. K. Mangum, student, and

Public Utilities, by Stanley McKinley, student. May 29. Attendance 16.

University of Arkansas

T. E. Peter and H. C. Claybaugh gave a report on the Regional Meeting in Dallas. D. J. Morrison elected Chairman for next year. May 17. Attendance 12.

Armour Institute of Technology

Illumination and Engineering, by Mr. Faulks, Curtis Lighting Co. April 8. Attendance 103.

Development and Manufacture of Loudspeakers, by Mr. Cling, Western Electric Co. April 22. Attendance 119.

Business Meeting. Following officers were elected for next year: Chairman, Jack Dollenmaier; Vice-Chairman, J. G. Papantony; Secretary, Stephen Janiszewski; Treasurer, Carl Rudelius. May 6. Attendance 65.

California Institute of Technology

Business Meeting. Election of officers for next year. May 16. Attendance 25.

Clemson Agricultural College

Chemistry and Electricity, by Cadet G. W. Sackman, and

Current Events, by Cadet J. H. Graves. April 11. Attendance 20.

Colorado Agricultural College

Business Meeting. Following officers elected for next year: Chairman, G. E. Branch; Vice-Chairman, J. P. Griffin. May 13. Attendance 10.

Annual spring inspection trip with A. S. M. E. Branch to Colorado Springs, Pueblo, and Denver. May 24. Attendance 36.

University of Denver

"Open House" Electrical Show. *The Accuracy of Walthour Meters at Various Power Factors*, by Joseph Cohen and J. N. Petrie; *Variation of the Pole Strength of a Permanent Magnet As Dependent upon Its Weight*, by F. A. St. John; *Visible Distribution of a Radio Wave along a Wire*, by Dale S. Cooper, and a *Demonstration of the Grid Glow Tube*, by J. L. Wright. Mr. Cato illustrated the detail of another practical "perpetual motion" machine. After the program the Physics Laboratories were inspected and refreshments were were served. May 2. Attendance 82.

University of Detroit

Practical Views on Arc Welding, by A. Robinson, Detroit Sales Mgr., The Lincoln Electric Co. Motion pictures—"From Mine to Consumer" and "Sheet Copper." May 28. Attendance 60.

Georgia School of Technology

Lightning and Its Relation to Transmission Lines, by C. E. Bennett, Georgia Power Co. May 15. Attendance 49.

Business Meeting. Following officers elected for next year: Chairman, L. B. Mann; Vice-Chairman, H. C. Vickery. May 21. Attendance 21.

Kansas State Agricultural College

A Graphical Solution of Networks, by E. G. Downie. May 2. Attendance 137.

University of Kansas

Brief talks by about ten seniors on the work they are to do after graduation. Refreshments served. May 23. Attendance 51.

Annual picnic of the electrical seniors. May 29. Attendance 25.

University of Kentucky

Business Meeting. Election of Officers. May 15. Attendance 51.

University of Louisville

Patents in Radio, by Mr. Kraprak. May 27. Attendance 24.

Marquette University

Business Meeting. Following officers elected: President, H. W. Haase; Vice-President, Amos Petit; Secretary, G. C. Reichert; Treasurer, George Maurer. April 18. Attendance 27.

Power Generation for Private Uses, by Prof. Frommelt, Head, Mechanical Engineering Dept. Prof. J. F. H. Douglas, Counselor, urged the students to prepare and present more papers. May 9. Attendance 22.

Michigan State College

Electric Arc Welding, by Mr. Willert. Illustrated lecture.

Electric Welding from a Construction Engineer's Viewpoint, by Mr. Henson, Civil Engg. Dept. Election of officers. May 8. Attendance 36.

School of Engineering of Milwaukee

Substation Operation, by F. W. Sulensky, Assistant Chief Operator, Milwaukee Elec. Railway & Lt. Co. May 14. Attendance 43.

University of Minnesota

Demonstration of Televox, by L. J. McCoy, Westinghouse Elec. & Mfg. Co. April 20. Attendance 600.

G. N. Anderson, Transmission Engr., Northwestern Bell Telephone Co., gave a lecture and demonstration on the effects of suppressing lower and higher frequencies in the reproduction of music and voice over transmission lines and the effects of trouble in telephone circuits. May 1. Attendance 155.

Missouri School of Mines & Metallurgy

Motion pictures, "Power Applications in the Bituminous Industry," "Panama Canal," "The Induction Voltage Regulator," and "Manufacture of Steel Ties." April 23. Attendance 28.

Montana State College

Election of officers: President, E. B. Wilson; Vice-President, E. G. Rudberg; Secretary, Otto Van Horn; Treasurer, Robert Jones. May 23. Attendance 71.

University of Nebraska

Regulation, by F. C. Curtis, Chairman, State Railway Commission. Joint meeting with A. S. M. E. Branch. Other engineering student societies invited. May 14. Attendance 40.

The Superheterodyne, Theory and Operation, by G. W. Cowley, student. Talks were given by the followng graduating seniors: Philip Fink, E. B. Hiltner, M. E. Scoville, Lester Shoemaker, and Malcolm Shoemaker. Mr. Bickley, Northwestern Bell Telephone Co., gave a short talk. Motion picture, "BTA. Alternating-Current Motor." Refreshments served. May 22. Attendance 29.

University of New Hampshire

Insulation, by H. Smith, student and

Luminous Steam, by P. Morton, student. May 4. Attendance 26.

Permissible Storage Battery Mine Locomotives, by J. Theall, student, and

Shaft and Rotor Assembly, by J. Terry, student. May 25. Attendance 27.

Motion picture on the story of copper, from mine to user. June 1. Attendance 28.

North Carolina State College

Business Meeting. Committee Chairmen were appointed for next year. May 21. Attendance 15.

University of North Carolina

Election of officers for next year. May 16. Attendance 27.

University of North Dakota

Airport Lighting, by Arthur Miller, student. May 22. Attendance 14.

Northeastern University

Talk by Prof. W. H. Timbie, Massachusetts Institute of Technology. Election of officers. May 28. Attendance 63.

Ohio Northern University

The Relations of Law and Engineering, by Dr. Small, Secretary of University. May 16. Attendance 24.

Ohio State University

Program was presented by the graduating students who reported upon their thesis work: *Altitude Measurements by Reflected Electromagnetic Waves*, by R. C. Newhouse; *Secrecy System for Carrier Current Telephony*, by E. R. Robinson; *Effect of Conductor Insulation upon the Critic Formation of Corona*, by Robert Spry; *Airport Illumination*, by G.W. Trout; *Effect of the Mixture of Light Waves upon the Speed of Vision*, by D. A. Warstler, and *Efficiency of High-Frequency Generators and Transmission Lines*, by J. D. Ryder. May 23. Attendance 40.

Oklahoma A. & M College

A brief report on the Regional Meeting at Dallas by E. L. Weathers, Chairman. Election of officers for next year. follows: Chairman, Hugh V. Anderson; Vice-Chairman, Wilbur E. Slemmer; Secretary-Treasurer, Early F. Neal. May 16. Attendance 18.

University of Oklahoma

A banquet was given by the Juniors in honor of the Graduating Electrical engineering students. Talks were given by the seniors. April 10. Attendance 44.

Smoker and general discussion pertaining to activities for next year. Election of officers for next year. May 20. Attendance 18.

Oregon State College

Joint meeting with Portland Section. (See report in Section Activities dept.). May 25.

Purdue University

Engineering and Patent Law, by A. M. Horn, Patent Attorney. Joint meeting with A. S. M. E. Branch. May 1. Attendance 45.

Rutgers University

Difficulties Students May Encounter with Motors, by Mr. Evans, Century Electric Co. April 30. Attendance 19.

A Trip to the General Electric Company's Plant, by W. Dalton, '29, and

The Organization of the Westinghouse Electric Plant, by Mr. Walton, '29. Business session. May 7. Attendance 20.

Air Blast Transformers, by A. S. Beams, '30, and

Long Distance Telephone Lines, by R. K. Shepard, '30. May 14. Attendance 18.

Election of officers. May 16. Attendance 21.

University of South Dakota

The Spectroheliscope, Spectroheliograph and Spectroscope, by Evire Lovejoy, student. May 21. Attendance 10.

Various Theories Formulated in the Last One Hundred Years Concerning the Structure of Matter, by Philip Miller, student. May 28. Attendance 12.

Stanford University

Smoker. Talks by Dr. C. D. Marx, Professor Emeritus of Civil Engg.; T. J. Hoover, Dean of the School of Engg. and Dr. Harris J. Ryan, Professor of Elec. Engg. The following officers were elected for next year: Chairman, D. A. Murray; Vice-Chairman, G. S. Kimball; Secretary-Treasurer, H. E. Hill; Member of Executive Committee, J. S. Low. Refreshments served. May 9. Attendance 47.

Operation of the Dial Telephone, by Mr. Becker, Palo Alto Office, The Pacific Tel. & Tel. Co. D. A. Murray, Chairman-elect, gave a brief talk and read President Schuchardt's message in the May issue of the JOURNAL. May 23. Attendance 20.

Inspection trip to Radio Station KPO, San Francisco. May 25. Attendance 10.

University of Tennessee

Election of officers for next year. May 15. Attendance 26.

University of Texas

The Future of an Engineer, by Prof. J. A. Correll, Counselor. Plans for next year were discussed and Prof. Correll offered several suggestions. Election of officers. May 16. Attendance 10.

University of Utah

Election of officers. May 7. Attendance 12.

University of Vermont

Business meeting. Officers for next year were elected as follows, and take office immediately: Chairman, F. E. Beckley; Vice-Chairman, R. F. Bigwood; Secretary-Treasurer, A. E. Merrill. May 8. Attendance 14.

Virginia Military Institute

Election of officers for next month. June 7. Attendance 32.

Virginia Polytechnic Institute

Labon Backer was elected Chairman to take office in September. May 22. Attendance 20.

University of Virginia

Prof. W. S. Rodman, Counselor, gave a brief talk concerning Branch work for next year. Election of officers for next year. May 20. Attendance 16.

Washington State College

Committee reports. April 17. Attendance 27.

Committee reports. May 8. Attendance 18.

Amendments to Branch By-laws adopted. Election of officers for next year. May 29. Attendance 27.

Washington University

Radio Broadcasting, by Thomas P. Convey, Station KWK, St. Louis. Smoker for students of the Branch, faculty members, and alumni. Engineers' Club of St. Louis. May 2. Attendance 80.

Officers elected for next year. May 16. Attendance 30.

University of Washington

The U. S. Army Ordinance, by Capt. L. P. Crim, U. S. Army Ordinance Dept. Slides. Election of officers for next year. Karl E. Hammer, Chairman for next year, gave a brief talk and presided. May 10. Attendance 14.

Business meeting. Voted to appropriate $25.00 for a research prize plaque. May 17. Attendance 20.

The Salmon Canning Industry in Alaska, by H. C. Hurlbut, student. May 24. Attendance 7.

University of Wisconsin

Recent Research Developments of the Westinghouse Electric & Mfg. Company, by C. E. Skinner, Asst. Director of Engineering of that company. Joint meeting with Madison Section. April 16. Attendance 12.

Worcester Polytechnic Institute

Television, by L. F. Cleveland, '29. R. W. Puddington gave a report on the Student Convention at Troy. Refreshments. May 21. Attendance 26.

Yale University

Science and Research in Telephone Development, by S. P. Grace, Asst. Vice-President, Bell Telephone Laboratories, Inc. Joint meeting with Connecticut Section. April 23. Attendance 2500.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these Founder Societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES, MAY 31, 1929

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

DIE ABWÄRMETECHNIK, bd. 3; Sondergebiete der Abwärmetechnik.

By Hans Balcke. Mün. u. Ber., R. Oldenbourg, 1928. 242 pp., illus., diagrs., 9 x 6 in., cloth. 13,50 r. m.

The third volume of Dr. Balcke's treatise on waste-heat engineering is devoted to methods of using waste heat in several important fields. These include its use for obtaining distilled feedwater for boilers, for concentrating liquids, for drying, for humidifying workrooms, and for refrigerating. Other matters discussed are its utilization on freight steamships, the utilization of excess electric energy, and modern measuring instruments and methods.

The three volumes form a very complete exposition of waste-heat engineering.

BEITRAG ZUR KLARUNG DER FRAGE, WIE DIE ASCHE NACH MENGE UND ART IM KOHLENSTAUB ENTHALTEN IST, UND WELCHE WEGE GEGEBEN SIND, SIE TROCKENMECHANISCH ZU BESEITIGEN.

By H. Schwartzkopff. (Fünfzehnte Berichtfolge des Kohlenstaubausschusses des Reichskohlenrates). Berlin, V. D. I. Verag, 1929. 24 pp., illus., diagrs., tables, 12 x 9 in., paper. 2,50 r. m.

The report of an investigation of the practicability of removing the ash from powdered coal by dry methods. The distribution of ash in powdered coal of various degrees of fineness was determined, as well as its character. Electrostatic, electromagnetic, and pneumatic methods of separation were examined. The conclusion was reached that dry methods of removing ash are not very efficient at present and would not be economical.

BUILDING ESTIMATORS' DATA BOOK.

By Charles F. Dingman. N. Y., McGraw-Hill Book Co., 1929. 159 pp., illus., tables, 7 x 4 in., fabrikoid. $2.50.

Tables are given for all the ordinary operations of building, with directions for their use. Carefully selected mathematical tables, formulas and constants are also included. The data are arranged for ready use with calculating machines and show in most cases the number of labor hours required for a given quantity of construction.

CONDUCTION OF ELECTRICITY THROUGH GASES.

By K. G. Emeléus. Lond., Methuen & Co., 1929. 94 pp., diagrs., tables, 7 x 4 in., cloth. 2/6.

This little monograph is designed to give an up-to-date outline of the main phenomena that can be studied quantitatively in connection with the passage of electricity through gases at low temperatures. It will be useful to those not in contact with recent work. A list of references is given for those who wish to pursue the subject further.

DIE DAUERFESTIGKEIT DER WERKSTOFFE UND DER KONSTRUKTIONSELEMENTE.

By Otto Graf. Berlin, Julius Springer, 1929. 131 pp., illus., diagrs., tables, 10 x 7 in., paper. 14.-r. m.

A review of our knowledge of the permanent strength of materials when subjected to repeated and long continued stresses. Brings together in convenient form the available results of tests by the author and other engineers. The materials discussed include steel, cast iron, cast steel, copper, nickel, aluminum, magnesium and their alloys, stone, reinforced concrete, wood, and glass.

EARTH FLEXURES; Their Geology, and their representation and analysis in geological section with special reference to the problem of Oil finding.

By H. G. Busk. Cambridge. Eng. University Press, 1929. N. Y., Macmillan Co. 106 pp., illus., diagrs., maps, 10 x 7 in., cloth. $4.00.

Modern development of the petroleum industry has created a demand for more exactitude and detail in geological methods of survey and section drawing. Mr. Busk here deals with one of the problems involved, that of section drawing.

His book aims to show how the information supplied from the geological map may be best applied, how geometric methods may be used for section drawing of folds, and what are the pitfalls that lie in the way of exactitude. In addition he illustrates his methods by an account of their application in Burmah, Persia, and the Sinai peninsula.

ECONOMICS OF COAL MINING.

By Robert W. Dron. Lond., Edward Arnold; [N. Y., Longmans, Green & Co.], 1928. 168 pp., diagrs., tables, 9 x 6 in., cloth. $4.20.

A concise review of the practical economic problems which confront those engaged in coal mining in Great Britain. The subjects discussed include mineral leases, the valuation of minerals and collieries, the development of new collieries, power production, capital expenditure, organization of the industry,

and coal cleaning. The author is vice-president of the Institution of Mining Engineers.

ELECTRIC WIRING, THEORY, AND PRACTICE.

By W. S. Ibbetson. 3rd edition. Lond., E. & F. N. Spon; N. Y., Spon & Chamberlain, 1929. 424 pp., illus., diagrs., 8 x 5 in., cloth. 7s 6d.

A clear description of the subject, giving much practical detail and covering all the matter needed in ordinary work. A good guide to current British practise.

ENGINEERING FOR MASONRY DAMS.

By William P. Creager. 2d edition. N. Y., John Wiley & Sons, 1929. 294 pp., illus., diagrs., tables, 9 x 6 in., cloth. $4.00.

The topics here discussed include the investigation of sites, the choice of type of dam, the forces acting on dams, the design of various types, the preparation of foundations, flood flows, details and accessories, and head-water control. The methods of design described and the assumptions recommended conform to conservative present practise.

DIE GRUNDBAUTECHNIK UND IHRE MASCHINELLEN HILFSMITGEL.

By G. Hetzell and O. Wundram. Berlin, Julius Springer, 1929. 399 pp., illus., diagrs., 10 x 7 in., bound. 35.-r. m.

A comprehensive survey of modern practise in foundation engineering and of machinery for building foundations. The engineering principles involved—kinds of soil, materials, earth pressures and bearing capacities—are presented, and the various methods of constructing foundations are described. About one-half of the book is devoted to contractors' machinery—cranes, conveyors, pumps, concrete mixers, pile-drivers, etc.

GRUNDLAGEN UND GERÄTE TECHNISCHER LÄNGENMESSUNGEN.

By G. Berndt. 2d edition. Berlin, Julius Springer, 1929. 374 pp., illus., diagrs., tables, 10 x 7 in., bound. 43,50 r. m.

This treatise, by the head of the Institute for Measurement and the Principles of Interchangeable Manufacturing at Dresden, surveys the scientific principles of measurement and the instruments for practical use. The evolution of the usual standards is described, and the methods by which shop and control standards of length are made and calibrated are discussed. Consideration is also given to the various types of gages and other measuring instruments that are used in industry, to their applications and exactness. Physiological errors in measurement and the reference of the meter to the wave-length of light are discussed in appendixes. The book contains a great amount of information on an important subject.

HISTORY OF MECHANICAL INVENTIONS.

By Abbott Payson Usher. N. Y., McGraw-Hill Book Co., 1929. 401 pp., illus., 9 x 6 in., cloth. $5.00.

This book is a systematic account of the development of the major mechanical inventions from their beginnings to the present time. Professor Usher's interest in the subject arises through its character as a basic element in economic history; as a result, he treats the subject in a broad way, with a minimum of technological detail, and with emphasis on matters of importance to society in general.

Introductory chapters discuss the place of technology in economic history and the process of mechanical invention. The early history of mechanical science and the mechanical equipment of antiquity are then described. Succeeding chapters trace the history of waterwheels and windmills, clocks and watches, printing, the textile industries, machine tools, and power production. A chapter is devoted to Leonard da Vinci. Excellent illustrations and a good bibliography are included.

INDUSTRIAL TRAFFIC MANAGEMENT.

By Leslie Aulls Bryan. Chic., A. W. Shaw Co., 1929. 392 pp., graphs, forms, 9 x 6 in., cloth. $4.00.

Aims to present the established economic principles of the subject in a form suited for a college text and for use as a reference work in practise. Discusses general principles, the details of organizing and administering industrial traffic, and the legal considerations involved.

INORGANIC CHEMISTRY FOR COLLEGES.

By William Foster. N. Y., D. Van Nostrand Co., 1929. 838 pp., illus., port., diagrs., tables, 9 x 6 in., cloth. $3.90.

Professor Foster's aim is to provide a textbook for college students who have studied the subject in the high school, and are thus prepared for a more advanced treatment of chemistry than beginning students. The book covers the usual ground, presenting the fundamental laws and theories, and the properties of the elements and their compounds, but the presentation is broader and more mature, as well as more thorough, than the usual college text.

INTERNATIONAL CRITICAL TABLES of Numerical Data, Physics, Chemistry, and Technology.

V. 4 & 5. N. Y., McGraw-Hill Book Co., 1928-1929. 2 v., 11 x 9 in., cloth. $12.00 each.

Two additional volumes of this great work will be welcomed by all scientific workers. Volume 4 contains phase-equilibrium data, osmotic pressures, and data upon surface tension, surface energy, and other properties of surfaces. Volume five has the numerical data of viscosity, specific heat, thermal conductivity, radiometry, photometry, and photography, and the properties of soaps and soap solutions. The data are based upon a critical study of all recorded observations and are indispensable to the investigator.

JAHRBUCH DER DEUTSCHEN GESELLSCHAFT FÜR BAUINGENIEURWESEN, 1928.

Berlin, V. D. I. Verlag, 1929. 227 pp., illus., port., diagrs., tables, 8 x 6 in., paper. 10.-r. m.

The yearbook for 1928, like its predecessors, combines with the proceedings of the society considerable matter of use to civil engineers which is not easily found elsewhere. Papers are included on modern processes for purifying sewage, on the Eickhoff Brothers' machine works, and on signals for railways, waterways, highways, and airways. Lists are given of the German laboratories for testing materials of important engineering projects completed in Germany during 1927 and 1928, of new German engineering standards and of dissertations presented to German universities for the degree of Doctor of Engineering during 1926 to 1928. There is also a report on the tests of wind pressures on framed structures carried out at the Goettingen Aerodynamic Institute.

JOURNAL, v. 2., pt. 1, January 1929, of the ROYAL TECHNICAL COLLEGE, GLASGOW. 155 pp., 10 x 7 in., paper. 10s 6d.

Among the papers of special interest to engineers are: tensile tests on rods and wires of the same iron, the magnetrostriction of various steels, the effect of annealing upon the solidus temperature of alloys, tempering changes in steels, the fuel-injection process in the air-injection oil-engine, the design of high-voltage condenser type insulator bushings, and the regional development planning of colonies.

LAW FOR ENGINEERS AND ARCHITECTS.

By Laurence P. Simpson and Essel R. Dillavou. St. Paul, West Publishing Co., 1929. 633 pp., 9 x 6 in., cloth. $4.50.

This textbook has been specially written to give the student of engineering or architecture a knowledge of the fundamental principles of law, illustrated by cases in which they are applied to those professions. The work is designed for the courses given at the University of Illinois.

The subjects treated include contracts, agency, workmen's compensation, mechanics' liens, property, regulation of public utilities, negotiable instruments, and sales. An appendix gives standard forms for building contracts, invitations to bidders, agreements between architect and owner, etc. The book will give the reader a knowledge of fundamental legal principles which will enable him to avoid many pitfalls and protect his interests.

MEMOIRS AND ADDRESSES OF TWO DECADES.

By Dr. J. A. L. Waddell. Edited by Frank W. Skinner. Easton, Pa., Mack Printing Co., 1928. 1174 pp., illus., port., tables, 9 x 6 in., cloth. $5.00.

This volume supplements the collection of Dr. Waddell's professional writings prepared about 25 years ago by Mr. John Lyle Harrington. It contains seventy-five papers, together with a biographical sketch and brief summaries of the papers in the earlier volumes.

The papers now presented consist of addresses and contributions to periodicals during the last 22 years. These are grouped under 11 headings—the engineering profession, ethics of engineering, engineering literature, alloy bridge steels, economics, bridge construction, contracts, railroads, Chinese matters, and miscellaneous topics. The volume shows in a most interesting way the broad field of activity that Dr. Waddell has covered in his busy career, while his excellent style affords a useful model for every young engineer who wishes to write.

MINING SUBSIDENCE.

By Henry Briggs. Lond., Edward Arnold & Co., N. Y., Longmans, Green & Co., 1929. 215 pp., illus., tables, 9 x 6 in., cloth. $5.50.

Professor Briggs gives a thorough discussion of this very

important subject. The theories of subsidence are reviewed critically, the records of subsidences in Great Britain, America, and India are discussed, and the effects of bending and shearing of strata are investigated.

NOUVELLES ETUDES SUR LA CHALEUR.

By Ch. Roszak and M. Véron. Paris, Dunod, 1929. 765 pp., 10 x 6 in., paper. 208 fr.

This book, the work of two well-known French specialists in heat and refrigeration, is devoted to some questions that have heretofore been studied only superficially, as well as to certain new problems.

The opening chapter explains why the development of heating apparatus is still embryonic. The authors then set forth the relations between the production of heat and cold and the conditions of life on the earth. From this they proceed to a study of the different ways by which heat is propagated, by mixing, conduction, convection and radiation. The results obtained in this theoretical study are then applied critically to modern steam generators, and directions in which improvement still seems possible are pointed out.

The remaining chapters discuss problems not connected with heat transmission, but of interest to the same engineers. They include a comparison of American and French rules for boiler construction, a discussion of district heating, and an account of Berthelot's method of hydrogenation, the basis of many recent processes for the synthesis of petroleum.

DIE ORGANISATION DER WÄRMEÜBERWACHUNG IN TECHNISCHEN BETRIEBEN.

By Hans Balcke. Mün. u. Ber., R. Oldenbourg, 1929. 312 pp., illus., diagrs., tables, 9 x 6 in., cloth. 17,50 r. m.

The chief purpose of this book is to guide the power-plant operator in the selection of instruments, methods and rules that will give him proper supervision and regulation of power-plant machinery. Methods of increasing efficiency of boilers, furnaces, gas producers and steam engines are given. Special attention is given to automatic regulation.

PETROLEUM AND COAL; the Keys to the Future.

By W. T. Thom, Jr. Princeton, Princeton Univ. Press, 1929. 223 pp., illus., maps, tables, 9 x 6 in., cloth. $2.50.

A clear, authoritative account of the principal industrial fuels, told briefly and in terms intelligible to the general reader. In an introductory chapter ancient and modern civilizations are compared, and the influence of these fuels upon national policies is discussed. The origin and occurrence of coal and oil, the coal and oil fields of the world, and the methods of discovering and working them are then described. The closing chapter discusses the size and adequacy of the remaining reserves and their bearing upon the future of civilization. The book will give those interested in public affairs a good picture of the situation, divested of details.

POLAR MOLECULES.

By P. Debye. N. Y., Chemical Catalog Co., 1929. 172 pp., 9 x 6 in., cloth. $3.50.

The dielectric and optical properties of molecules when subjected to an external electrical field are the subject of this monograph. Dr. Debye has brought together the widely scattered literature, and offers a comprehensive review of our experimental and theoretical knowledge.

POWER RESOURCES OF THE WORLD; potential and developed.

By International Executive Council. World Power Conference, London. Lond., World Power Conference, 1929. 170 pp., tables, 10 x 6 in., cloth. $4.25.

This important monograph has two purposes. It first aims to coordinate the available information on the coal resources, water power, and oil of the world, and on electric power production. Its second purpose is to indicate inequalities and omissions in the various systems for assessing power resources, and thus to further the adoption of uniform methods that will enable an accurate appraisal to be made.

The book brings together the best available estimate of our present and potential power resources. It also contains a bibliography of the power resources of the world, covering the period 1924 to 1928.

PROFESSOR COKER'S PHOTOELASTIC APPARATUS.

Lond., Adam Hilger, Ltd., 1929. 28 pp., illus., 10 x 6 in., paper. Price not quoted.

This pamphlet describes a method for investigating stresses in structures for which no mathematical solutions are available, by observations, under polarized light, on models made of transparent materials, such as celluloid or glass. The method is applicable to a great variety of engineering problems.

The apparatus invented by Professor Coker is described in detail and the method of use explained.

PYROLYSIS OF CARBON COMPOUNDS.

By Charles D. Hurd. N. Y., Chemical Catalog Company, 1929. (Amer. Chemical Society. Monograph series). 807 pp., tables, 9 x 6 in., cloth. $12.50.

Professor Hurd has attempted to survey completely and organize rationally the voluminous, scattered literature upon the transformations produced in organic compounds through the agency of heat alone. His large monograph will be of great value to all workers in this important field, who will find here a thorough review of what is known with references to the original publications.

SEVEN PLACE NATURAL TRIGONOMETRICAL FUNCTIONS.

By Howard Chapin Ives. N. Y., John Wiley & Sons, 1929. 222 pp., tables, 7 x 4 in., fabrikoid. $2.50.

A compact set of tables which includes those most frequently wanted by surveyors and railroad engineers. The growing use of calculating machines for computations makes these tables of natural functions most welcome.

SIEMENS JAHRBUCH, 1929.

By Siemens & Halske, & Siemens-Schuckertwerke. Berlin, V. D. I. Verlag, 1929. 644 pp., illus., port., diagrs., tables, 8 x 6 in., cloth. 12.-r. m.

The new issue of this handsome annual follows the plan of previous years, of presenting in nontechnical language accounts of important scientific and technical advances recently made by the Siemens concerns. Contributions on telegraphy, electrochemistry, steam turbines, heavy-duty switchgear and many other branches of electrical engineering are included. Of historic interest are several letters written fifty years ago by Werner von Siemens to his brothers, and papers on electric mine locomotives, Pupin coils, and automatic telephony.

SONS OF MARTHA; a historical and biological record covering a century of American Achievement by an organization of master builders.

By Dixon Merritt. N. Y., Mason & Hangar Co., 1928. 319 pp., illus., ports., 8 x 6 in., cloth. $3.00.

A history of the well-known contracting firm, the Mason & Hanger Company, and its predecessors. The founder, Claibourne R. Mason, took his first road contract in 1819. The organization built many railroads, chiefly in the South, and participated in the construction of the Chicago Drainage Canal, the Catskill Water System, and the Port Newark Terminal. Other important work entrusted to it include the Charleston Port Terminal, the Old Hickory powder plant, and the foundations of the Fort Lee Bridge.

STATISTIK DER ELEKTRIZITÄTSWERKE UND DER ELEKTRISCHEN BAHNEN OSTERREICHS. 1927.

By Elektrotechnischer Verein in Wien. Wien, Verlag des Elektrotechnischen Vereines, [1929]. 188 pp., map, 12 x 9 in., boards. 20s (Austrian).

Presents the statistics of more than 800 electric power plants and 33 electric railroads in Austria, as of the end of 1927. These are arranged both alphabetically and geographically.

STATISTISCHER QUELLEN-NACHWEIS FÜR DIE DURCHFÜHRUNG VON MARKTANALYSEN.

By A. Reithinger. Berlin, V. D. I. Verlag, 1929. (Wirtschaftlicher Vertrieb, heft 1). 45 pp., 9 x 6 in., paper. 3,50 r. m.

A guide to the official statistics of Germany, compiled from the point of view of those engaged in market analysis. The statistical publications of use for this purpose are indexed alphabetically under appropriate subjects, so that the user can readily ascertain what is available on any subject and where it will be found.

TASCHENBUCH FÜR FERNMELDETECHNIKER.

By Hermann W. Goetsch. 4th edition. Mün. & Ber., R. Oldenbourg, 1929. 526 pp., illus., diagrs., 7 x 5 in., cloth. 13.-r. m.

The Taschenbuch für Fernmeldetechniker is a convenient ready reference work on telegraphy, telephony and electric signaling over wires. The theoretical principles, the design and installation of the apparatus, and the operation and testing of systems is covered practically, with considerable detail. Space is given to electric pyrometers, burglar alarms, railroad and mine signals, clocks, and other recording and signalling apparatus. Printing and sound telegraphs are discussed. The book is an excellent description of German practise.

VENTILATION OF MINES; Generation of the Air Current.

By Henry Briggs. Lond., Methuen & Co., 1929. 136 pp., illus., diagrs., tables, 8 x 5 in., cloth. 7/6.

Contains the substance of a series of lectures delivered in the Royal School of Mines in 1927. Professor Briggs treats of the design and application of the ventilating machines and appliances used in modern mining practise, giving special attention to recent developments. No attempt is made to be exhaustive, but attention is given especially to those matters which are often not understood.

WALZWERKSWESEN, v. 1.

Edited by J. Puppe & G. Stauber. (Handbuch des Eisenhüttenwesens). Düsseldorf, Verlag Stahleisen; Berlin, Julius Springer, 1929. 777 pp., illus., plates, diagrs., tables, 11 x 8 in., cloth. 85.-r. m.

This is the first volume of the most exhaustive treatise on the rolling of iron and steel that has ever been published. The work has been prepared under the auspices of the German Society of Ironmasters, by a number of well-known specialists under the leadership of J. Puppe. When complete it will comprise four volumes.

The work is designed to be a complete treatise on rolling-mill practise. While special attention will be given to technical matters, economic and scientific matters will also be considered, so that the book will summarize completely our present knowledge in this field.

Volume I contains: the national and international economic importance of rolling-mills, by Drs. Reichert and Buchmann; the historical evolution of rolling, by Dr. Johannsen; the constitution and properties of malleable and rollable iron, by Drs. Oberhoffer and Esser; the constitution of metals, by Dr. Hengstenberg; testing of materials, by Dr. Moser; specifications and standards, by Dr. Schulz; cost accounting, by Dr. Jordan; operating statistics and supervision, by Drs. Jordan and Rummel; the rolling process, by Dr. Koerber; rolls, by Dr. Emicke; and roll trains, by Dr. Puppe.

Succeeding volumes will discuss the rolling of various products, heating furnaces, conveyors, cranes, and other accessories.

ZUGBILDUNGSKOSTEN, ZUGFÖRDERKOSTEN UND IHRE WECHSELBEZIEHUNGEN.

By G. Capelle, A. Baumann, and R. Feindler. Berlin, Guido Hackebeil [1929]. 142 pp., graphs, tables, 9 x 6 in., paper. 3.-r. m.

The interrelations between the cost of making up trains and the cost of running them have been carefully investigated by these authors for the German National Railroad Company. Their findings are given in full detail in this report, which analyzes the various operations involved and determine the influence of each on the total cost of operating trains and discusses the correlation between running and making up trains. The report is a valuable document on the subject.

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contribution from the societies and their individual members who are directly benefited.

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1216 Engineering Bldg., 205 W. Wacker Drive, Chicago, Ill., A. K. Krauser, Manager.
57 Post St., San Francisco, Calif., N. D. Cook, Manager.

MEN AVAILABLE.—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to **EMPLOYMENT SERVICE, 31 WEST 39th Street, New York City,** *and should be received prior to the 15th day of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary: temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

POSITIONS OPEN

GRADUATE ASSISTANTSHIPS, open to graduates in electrical engineering. Positions permit half time to be devoted to the pursuit of graduate work in electrical engineering toward the degree of Master of Science. The other half time is assigned to teaching duties in the electrical engineering laboratory. Period of service is from September 20th to June 20th. Apply by letter. Salary $800. Location, Middle West. X-8383-S-R-410-C.

PROFESSOR OF ELECTRICAL ENGINEERING, to begin September 20, 1929. Must be a wide-awake, progressive man of both practical and teaching experience. Must have a degree in Electrical Engineering and in addition a Master's degree. Must be capable of carrying graduate and research work, and also willing to carry a reasonable amount of junior and senior undergraduate work in electrical engineering. Other things being equal, preference would be given to a man with some experience in transmission and distribution. Must be mathematically minded and no one will be considered who cannot qualify as a superior teacher. Important that he be of congenial disposition and have a sympathetic attitude toward students. Apply by letter. Location, Middle west. X-8384-S-R-411-C.

ENGINEER, experienced, graduate preferred, to assist in the development of intricate automatic machinery, also involving electrical control, essential to basic industry and in large and increasing use. Apply by letter. Location, Middle west. X-8551-C.

ELECTRICAL ENGINEERING GRADUATE OF UNIVERSITY, of recognized standing desired by middle west utility. Applicant should have from one to five years' experience in electrical utility work and should have superior mathematical, technical and analytical ability to properly qualify him for the wide variety of engineering studies made by company. Apply by letter. Location, Middle West. X-8396-S-R-409-C.

ELECTRICAL DRAFTSMEN, technical graduates, experienced in out-door high tension substation design preferred. Apply by letter giving complete details of education and experience and enclose recent photograph. Salaries $150-$200 a month. Location, South. X-8508.

ENGINEER, with a leaning toward economics and some electrical or mechanical engineering training. Work will be comparing actual costs against estimates, tracing cause of high costs and assisting department heads in cost reduction, etc. Apply by letter giving experience, age, earning ability and other facts which will help decide whether an interview will be mutually profitable. Location, Middle West. X-8456-C.

ELECTRICAL ENGINEERS, young, recent graduates, who had good scholastic standing and have had experience in engineering, construction, operation or the manufacture of equipment for power companies. Must be capable of doing general engineering and station design work. Apply by letter. Location, Middle west. X-8546-C.

MEN AVAILABLE

ELECTRICAL ENGINEER, over 15 years' experience in electric light and power field; several years in charge of work, desires position in charge of electrical engineering work for central station company, either with or without construction and operating duties. University graduate, with good technical knowledge and ability to handle men. B-1923.

ELECTRICAL ENGINEER, graduate, desires position with manufacturing concern, public utility, or contractor; 18 years' experience in the

electrical industry, 10 of which, up to date, connected with the largest public utility company. Design, construction, maintenance, power houses, sub-stations, distribution, handling materials, specifications, etc. Location desired, here or abroad. C-6055.

ENERGETIC ELECTRICAL ENGINEER, Cornell graduate, 30, married, now employed, wants greater opportunity, willing to start low; six years' experience with large public utility on general, power plant testing, and relay protection engineering, both field and office work. Has executive ability, highly technical, agreeable personality. Desires permanent connection with high-class public utility or manufacturing concern. Location, immaterial except South. Present salary $350. C-6096.

MAINTENANCE ENGINEER, technical education in electrical engineering, 35, married; 12 years' experience in construction of power plants and substations, maintenance, tests and one year operating a small plant. Good knowledge of equipment, cooperative ability, desires position with industrial or manufacturing organization, public utility or construction engineers. Now employed in East. Location, immaterial References, present employer. C-2021.

ELECTRICAL AND STRUCTURAL ENGINEER. Eighteen years' power plant experience with engineers, contractors, public utilities as designer, supervising engineer and consultant in domestic and Latin-American field. Specialist on high-tension transmission lines, outdoor substations. Desires position as executive in engineering or administrative work. Location, immaterial. C-5824.

ELECTRICAL ENGINEER, 22, single, 1928 graduate with degree of B. E. E. with honors; 1½ years' experience in testing. Desires position with industrial and construction company or public utility, with opportunity. C-6039.

GRADUATE ELECTRICAL ENGINEER would like to make a substantial connection with industrial firm or public utility as an engineer or assistant to Electrical Engineer or Superintendent of Operation. Two years' Westinghouse test; five years' industrial electrical engineering experience; five years electrical design, drafting and operation of power plants and substations; also familiar with transmission line calculations. B-8379.

ELECTRICAL ENGINEER, 40, married, 20 years' broad experience testing, design, construction, and supervision with well-known corporations; one year teaching, desires permanent position with responsible company on construction or operation. Location, United States, South preferred. B-1473.

SALES EXECUTIVE, a business getter, 40, with broad knowledge of production construction and sales and a record as a successful sales engineer, district manager and assistant sales manager will consider position leading to a sales or district managership in either electrical or mechanical lines. B-3065.

ELECTRICAL ENGINEER, 35, married, with twelve years' public utility operating and management experience desires public utility connection. Available on reasonable notice. C-6120.

EXECUTIVE MANAGER, electrical and mechanical. 24 years' successful experience, including teaching leading university; engineer Westinghouse; engineer, utility commission, public utility electrical and mechanical engineer and Manager last eleven years. Completely rebuilt power plant and distribution; made new rate schedules and personally handled sales of large power customers. Middle West preferred. B-7848.

GRADUATE ELECTRICAL AND MECHANICAL ENGINEER with two years of post-graduate work in physics. Desires position as research or consulting engineer. Ten years' experience in high-tension and automatic devices and some X-Ray work. Has executive and organizing ability. Desires position as designing engineer where facilities for research are available. Location, United States or abroad. B-9408.

ELECTRICAL ENGINEER, 24, single, six months general testing, two and a half years design of rural and city distribution. Desires connection in a distribution department with a future. Available on reasonable notice. Location preferred, East. C-5454.

ELECTRICAL ENGINEERING TEACHER with nine years' teaching experience desires position above the grade of instructor where an opportunity can be had of completing work for doctor's degree. Has M. S. degree and General Electric Test, as well as teaching and research experience. B-660.

CHIEF ENGINEER, Industrial Plant. Graduate of Pratt Institute, 38, married. Experienced in electrical wiring and maintenance, computing generation costs and making tests of boiler efficiencies. Desires a position offering opportunities for advancement. Prefer Connecticut or in or about New York City. C-4404.

MEMBERSHIP—Applications, Elections, Transfers, Etc.

APPLICATIONS FOR TRANSFER

The Board of Examiners, at its meeting held June 19, 1929, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grade of Member

BRYANT, ROGER H., Electrical Engineer, American Steel & Wire Co., Worcester, Mass.

CHADBURN, RALPH W., Asst. Supt., Standardizing and Testing Dept., Edison Elec. Ill. Co. of Boston, Boston, Mass.

DIKE, PERCY R., Designer, Commonwealth Edison Co., Chicago, Ill.

DOUGLAS, JOHN A., Instructor, Educational Bureau, Brooklyn Edison Co., Brooklyn, N. Y.

DUDLEY, CARLTON L., Engineer, Public Service Elec. & Gas Co., Newark, N. J.

EYNON, STUART J., Meter and Instrument Engg. Dept., General Elec. Co., Lynn, Mass.

FRANKENBERRY, THOMAS H., Transformer Design Engineer, Westinghouse Elec. & Mfg Co., Sharon, Pa.

FRITZ, HARRY R., General Transmission and Protection Engineer, Southwestern Bell Telephone Co., St. Louis, Mo.

GILBERT, JOHN J., Electrical Engineer, Bell Telephone Labs., New York, N. Y.

GODDARD, MYRON C., Member of Technical Staff, Bell Telephone Labs., New York, N. Y.

HENRY RAYMOND T., Asst. Elec. Engr., Niagara Falls Power Co., Niagara Falls, N. Y.

HILL, LELAND H., Manager, Transformer Division, American Brown Boveri Elec. Corp., Camden, N. J.

HILLHOUSE, A. S., Consulting Engineer, Cleveland, Ohio.

KESSEL, HERBERT, Asst. Chief Engineer, Fairbanks Morse & Co., Indianapolis, Ind.

KRUSE, ROBERT S., Consulting Engineer, West Hartford, Conn.

LECLAIR, TITUS G., Asst. Engr., Commonwealth Edison Co., Chicago, Ill.

LOGAN, MAURICE H., Division Substation Operator, Public Service Elec. & Gas Co., Jersey City, N. J.

MILLER, KENNETH W., Asst. Head Engr., Technical Division, Street Dept., Commonwealth Edison Co., Chicago, Ill.

NELSON, ARTHUR R., Asst. to Division Supt., Public Service Elec. & Gas Co., Trenton, N. J.

OTTEN, HARRY O., Asst. Supt. of Substations, United Electric Light and Power Co., New York, N. Y.

PENGILLY, Secretary-Treasurer, Diamond Electrical Mfg. Co., Los Angeles, Cal.

PORTER, GEORGE McC., Associate Professor of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

PUGH, EMERSON, Electrical Engineer, Western Electric Co., Chicago, Ill.

RICHARDSON, A. N., Operating Supt., Illinois Northern Utilities Co., Dixon, Ill.

ROBERTS, L. S., General Exchange Supervisor, Southwestern Bell Telephone Co., St. Louis, Mo.

SALTER, ERNEST H., Engineer in charge, Cable Research, Electrical Testing Labs., New York, N. Y.

SUYDAM, C. H., Acting Chief Engineer, Federal Telegraph Co., Palo Alta, Calif.

THOMAS, EVERETT E., Application Engineer, General Electric Co., Schenectady, N. Y.

THOMAS, BENJAMIN F., Consulting Engineer, Exchange Building, St. Louis, Mo.

WEIR, PAUL L., Designer of Transmission Lines and Structures, Byllesby Engg. & Mgt. Corp., Pittsburgh, Pa.

WILDES, KARL L., Asst. Prof. of Elec. Engg., Mass. Inst. of Technology, Cambridge, Mass.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before July 31, 1929.

Beardow, G. M., Bell Telephone Laboratories, Inc., New York, N. Y.

Becker, L. W., Lieut., (Member), *U. S. S. Mississippi*, San Francisco, Calif.

Berman, M. E., General Electric Co., Detroit, Mich.

Bricker, E. E., Pacific Tel. & Tel. Co., San Francisco, Calif.

Broecker, A. F., Kimberly-Clark Corp., Neenah, Wis.

Burnett, J., (Member), Pacific Electric Clock Co., Inc., Berkeley, Calif.

Conway, J. O., Electrical Research Products, New York, N. Y.

Crump, T. W., International Business Machine Corp., Charlotte, N. C.

D'Hyevre, A., Detroit Edison Co., Detroit, Mich.

Dickins, R. C., Canadian National Telegraphs, Sioux Lookout, Ont., Can.

Dixon, L., New York Central Railroad Power Station, New York, N. Y.

Duphorne, H. M., Southwestern Bell Telephone Co., Oklahoma City, Okla.

Elsdon-Dew, A. E., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Fitzgerald, J. D., General Electric Co., Chicago, Ill.

Foster, J. E., Long Island Lighting Co., Roslyn Heights, N. Y.

Frankhouser, D. C., Bennington Electric Co., Curwensvill , Pa.

Frenz, H. J., Victor Talking Machine Co., Camden, N. J.
Fullerton, D. P., Jr., Electrical Research Products, Inc., New York, N. Y.
Gray, S. K., Dayton Power & Light Co., Dayton, Ohio
Gray, W. T., Jr., Northwestern University, Evanston, Ill.
Hecht, W. C., Bell Telephone Co. of Penna., Pittsburgh, Pa.
Heim, E. F., (Member), 1800 "E" St., N. W., Washington, D. C.
Horspool, G., Calgary Power Co., Ltd., Seebe, Alberta, Can.
Jacobson, M., Jordan Marsh Co., Boston, Mass.
Keen, A. H., General Electric Co., Dallas, Tex.
Keiper, R. C., Bethlehem Steel Co., Allentown, Pa.
Kelter, J. C., Harry Alexander, Inc., New York, N. Y.
Labunski, C. M., Detroit Edison Co., Detroit, Mich.
La Cauza, F. E., Harvard University, Cambridge, Mass.
Lane, A. M., Pacific States Electric Co., San Francisco, Calif.
Lawrence, R. E., J. G. White Engg. Corp., Boling, Tex.
Legg, B. B., (Member), Columbia Engineering & Management Corp., Columbus, Ohio
Lowe, H. D., Electrical Research Products, Inc., Hollywood, Calif.
Ludwell, F. R., Pacific Electric Mfg. Co., San Francisco, Calif.
Manning, R. P., Westchester Lighting Co., Mount Vernon, N. Y.
McCarthy, J. J., Cleveland Rilway Co., Cleveland, Ohio
McNulta, L. F., New York Telephone Co., New Rochelle, N. Y.
Meeker, H. A., Meeker Electric Co., Williston Park, N. Y.
Mikelberg, S., Stone & Webster Corp., Boston, Mass.
Miller, D. S., 225 Greenfield St., Hartford, Conn.
Mullen, J. T., Southwestern Bell Telephone Co., Kansas City, Mo.
Powell, E. M., Westinghouse Elec. & Mfg. Co., Wilkes-Barre, Pa.
Raine, R. W., American Electric Co., Miami, Fla.
Reed, G. L., Western New York Gas & Electric Corp., Lancaster, N. Y.
Schlossberg, V. E., Inland Steel Co., East Chicago, Ind.
Schneider, R. G., Harry D. Payne, Houston, Tex.
Shortt, J. F., Corporation of Penticton, Penticton, B. C., Can.
Stephenson, D. C., Northern Light & Power Co., Indian Head, Sask., Can.
Sweet, D. M., Public Service Co. of No. Illinois, Chicago, Ill.
Vogel, O. S., Georgia Power Co., Atlanta, Ga.
Watkins, N., U. S. Government, Wright Field, Dayton, Ohio
Watts, W., Lehigh Portland Cement Co., Oglesby, Ill.
Weber, G. A., City Hall, Palo Alto, Calif.
Welter, G., American Brown Boveri Electric Corp. Camden, N. J.
Wheeler, H. J., General Electric Co., Schenectady, N. Y.
Williams, W. K., Dallas Power & Light Co., Dallas, Tex.
Wray, T., Simplex Wire & Cable Co., Cleveland, Ohio
Total 55.

Foreign

Brown, A. F., c/o Anglo Persion Oil Co., Abadan, Persian Gulf.
Buck, E. C., (Fellow), British Engineering Manufacturers' Alliance Ltd., Port of Spain, Trinidad, B. W. I.
Deane, H. E., Electrical Contractor, P. O. Box 273, Bridgetown, Barbados, B. W. I.
Dewis, J. H., Rustor & Hornsby Ltd., Sydney, Australia
Faber, C. W., Rio de Janeiro Tramway Light & Power Co., Rio de Janeiro, Brazil, So. America
Ganguli, A. K., East Indian Railway Electric Power Sta., Cawnpore, India
Gopinath, S. K., M. & S. M. Railway Workshops, Perambur, Madras, India
Harvey, A. H., Energia Electrica de Cartagena, Cartagena, Colombia, So. America
Kirkpatrick, H. J., Rio de Janeiro Tramway Light & Power Co., Rio de Janeiro, Brazil, So. America
Lambert, S., Porcelainerie de Lesquin, Paris, France
Rao, K. N., (Member), Municipal Electrical Engineer, Hindupur, Anantapur District, So. India
Rawal, T. R., Anglo Persian Oil Co., Ltd., Masjid-I-Sulaiman, S. W. Persia
Vanden Meersche, A. J., University of Ghent, Ghent, Belgium
Webb, T. F., Standard-Waygood, Ltd., Clyde, N. S. W., Australia
Total 14.

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Brady, Elisha E., University of Oklahoma
Bridges, Josiah A., Stanford University
Brown, William B., Newark Coll. of Engineering
Buchanan, Lloyd C., State College of Washington
Cain, Doyle E., University of Texas
Calcagni, Levio, University of Vermont
Caldwell, Colonel L., State College of Washington
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Carter, Hubert C., Emory University
Castano, Francisco, Georgia School of Technology
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Center, Clare E., Worcester Polytechnic Institute
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Cooper, Marvin L., University of Missouri
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Davidson, John W., Worcester Polytechnic Inst.
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DeVries, Lawrence H., Michigan State College
DiToro, Michael J., Brooklyn Polytechnic Institute
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Elliott, William E., Georgia School of Technology
Evans, L. H., Jr., Texas A. & M. College
Ewing, Chester A., Massachusetts Institute of Technology
Fenton, Earl L., North Dakota Agricultural College
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Kouyoumdjian, Vahram, Robert College
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Livie, Jack, State College of Washington
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Orphanides, Christ L., Worcester Polytchnic Institute
Owen, Lucien E., Alabama Polytechnic Institute
Parsons, Marshall F., Michigan State College
Pearce, Heyward, University of Michigan
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Phanuef, Edgar A., Worcester Polytechnic Institute
Puddington, Roy W., Worcester Polytechnic Institute
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Torkelson, Elmer O., North Dakota Agricultural College
Vines, Quentin C., University of Illinois
Walraven, Madison M., Georgia School of Technology
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Will, August J., South Dakota State College
Williamson, Harold G., Worcester Polytechnic Institute
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(A list of the personnel of Institute committees may be found in the June issue of the Journal.)

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(The Institute is represented on the following bodies; the names of the representatives may be found in the June issue of the Journal.)

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DIGEST OF CURRENT INDUSTRIAL NEWS

NEW CATALOGUES AND OTHER PUBLICATIONS

Mailed to interested readers by issuing companies

Gang Operated Switches.—Bulletin 1-I. Describes an improved type of air break gang-operated switch with voltages up to 220 kv. The Champion Switch Company, Kenova, West Va.

Outdoor Switching Equipment.—Bulletin GEA-1029A, 12 pp. Describes group-operated, rotating-insulator, disconnecting switches. General Electric Company, Schenectady, N. Y.

Motor Starters.—Bulletin, 4 pp. Describes EC & M automatic synchronous motor starters. Illustrations showing typical applications are included. Electric Controller & Mfg. Company, Cleveland, Ohio.

Panelboards.—Catalog 224, 64 pp. Describes the new Westinghouse line of panelboards, including type NAB Nofuz panelboard using the 15 ampere, Deion principle circuit breaker. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

Disconnecting Switches.—Bulletin "E". Describes outdoor disconnecting switches from 400 to 3000 amperes for various commercial voltages. Champion Switch Company, Kenova, W. Va.

Large Pipe Welding.—Bulletin 505, 52 pp., "The New Way." Describes automatic, arc-welded volume production of pipe for oil and gas lines. According to the bulletin, 2500 miles of such pipe have been manufactured or are on order. A. O. Smith Corporation, Milwaukee, Wis.

Supervisory Control.—Bulletin 1834, 12 pp., on synchronous visual supervisory control. Describes present types of Westinghouse supervisory control units giving their application, advantages and system of operation. The bulletin is well illustrated with typical control equipment. Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa.

Fuse and Disconnecting Switches.—Bulletin 503, 28 pp. Describes Matthews fuswitches and disconnecting switches housed in cypress wood. Bulletin 504, 32 pp. describes similar equipment, but of open type. Both bulletins are profusely illustrated, showing the latest improvements in the complete line. W. N. Matthews Corporation, St. Louis, Mo.

Circuit Breakers.—Bulletin 600, 20 pp. Describes type "O" oil switches and circuit breakers in capacities from 200 to 2000 amperes, from 2500 to 15,000 volts and with interrupting capacities from 20,000 to 40,000 kv-a. They are made as two-pole and three-pole devices, automatic and non-automatic, single and double throw, for switchboard, wall and cell mounting; also for hand operation, normal and remote control and electrical operation. All necessary styles of trips and all the usual auxiliaries required in oil switch operation are available. Roller-Smith Company, 233 Broadway, New York.

Traffic Control.—Bulletin "Miller Traffic Control," 18 pp. Describes the Miller "Traflator," a new system for which is claimed all of the benefits of the arbitrarily time traffic systems, and in addition halts traffic only when necessary. The "trafl ator" is composed of three units, the detector, a combination relay and rectifier, and a condenser. The detector is a vehicle detecting device which is buried in the street so that the top does not extend above street level. It operates on the magnetics Wheatstone Bridge principle also employed in the Miller Induction System of Train Control now in successful operation on railroads. Traflators are unlimited in their applications; they do not supplant but work in conjunction with, and may be added to, any standard signal system. They are universally adapted to any signaling condition, and their use will prevent long, unnecessary stops and give ultimate street capacity consistent with safety at any intersection regardless of whether it is an isolated intersection or a part of an interconnected system. The Miller Train Control Corporation, Staunton, Va.

NOTES OF THE INDUSTRY

The Copperweld Steel Company, Glassport, Pa., has formed a southeastern district comprised of Georgia, Alabama, Tennessee, Florida, Mississippi, and part of Louisiana, with P. A. Terrell in charge as district manager. The office of this district is located in the American Traders Bank Building, Birmingham, Alabama.

Delta-Star Buys Foundry.—H. W. Young, president of the Delta-Star Electric Company, Chicago, announces the purchase of the buildings and equipment of the Howard Foundry and Pattern Shops with which will be combined the present Delta-Star foundry. This addition to Delta-Star's foundry facilities will insure adequate production of copper, aluminum, manganese bronze and brass castings.

Century Electric Acquires Roth Bros.—The Century Electric Company has purchased Roth Brothers & Company, Chicago, Ill., manufacturers of motors and generators and motor generator sets. While Roth Brothers & Company will be operated as a division of the Century Electric Company, some of its products will now be manufactured in the Century Electric Company's plant in St. Louis. The acquisition of Roth Brothers & Company will result in broadening the Century Company's already influential position in the electrical apparatus manufacturing field, by supplementing its line of polyphase induction industrial power motors and its line of single-phase motors in which it has pioneered, and which have contributed to making possible the rapid development and popularity of the household refrigerator and many other widely used devices.

Manufacturers Join NEMA.—Fifteen manufacturing companies have joined the National Electrical Manufacturers Association and are affiliated in eleven sections according to an announcement from NEMA Headquarters. The manufacturers and their section affiliations are as follows:

Wire and Cable Section: Gavitt Mfg. Co., Globe Insulated Wire Co.; Carbon Arc Lamp Section: A. S. Aloe Co., Hibner Electric Co.; Switchgear Section: Line Material Co.; Molded Insulation Section: Mack Molding Co., The Recto Mfg. Co., Union Insulating Co.; Lamp Receptacle and Socket Section: John I. Paulding, Inc.; Electric Measuring Instrument Section: Standard Transformer Co.; Laminated Phenolic Products Section: Synthane Corp.; Rigid Conduit Section: Walker Brothers; Carbon Section: Pure Carbon Co.; Electric Range and Heating Section: Automatic Electric Heater Co.; High Voltage Insulator Section: Porcelain Insulator Corporation.

Colleges Represented in the General Electric Company.—More than 4400 college graduates, representing approximately 215 American universities, colleges and technical schools, are in the employ of the General Electric Company. The figures include only those who completed a course for a degree.

In training, the classification includes: Electrical engineering, 3278; mechanical engineering, 529; civil engineering, 71; chemical and ceramic, 132; metallurgical, mining and physics, 53; aeronautical, radio and marine, 12; general engineering, 142; scientific, 98; liberal arts, 272; business administration, law, etc., 178. The term "general engineering" includes administrative, agricultural, architectural and industrial engineering, and U. S. Naval Academy engineering.

By departments, the college graduates are classified as follows: District offices, 1062; general office commercial departments, 349; general office commercial engineering departments, 197; engineering and drafting, apparatus works, 1167; manufacturing, apparatus works, 520; general engineering and Schenectady laboratories, 200; general manufacturing, 27; general accounting, 139; other general administrative departments, 66; merchandise department, 43; electric refrigeration department, 34; International General Electric Company, 179; incandescent lamp department, 333; and first year test men at Schenectady and elsewhere, 449.

JOURNAL OF THE A I E E

DEVOTED TO THE ADVANCEMENT OF THE THEORY AND PRACTISE OF ELECTRICAL ENGINEERING AND THE ALLIED ARTS AND SCIENCES

The Institute is not responsible for the statements and opinions given in the papers and discussions published herein. These are the views of individuals to whom they are credited and are not binding on the membership as a whole.

Vol. XLVIII AUGUST, 1929 Number 8

A Message From the President.

Interrelationship of the Institute and the Individual Member.

AMONG the various objects and functions of the American Institute of Electrical Engineers, the following are definitely stated: "*the advancement of the theory and practise of electrical engineering and the allied arts and sciences, the maintenance of high professional standing among its members and the development of the individual engineer.*"

Founded forty-five years ago, almost as a local organization naturally centering about New York City, where it found membership with which to gather strength for the great future it had undertaken, the Institute nevertheless was small and feeble in its activity and influence, although definite in its ultimate purpose as evidenced by the above statement. During the first fifteen years of its life, when it had not yet attained a total membership of three thousand—less than the membership of each of several of its present districts—it laid much of its present foundation.

As a result of adherence to these three fundamentals, which are here emphasized, the Institute's activity, prestige and personnel have developed until for a long time it has been national in its scope with membership now approaching twenty thousand. In furtherance of these purposes, but few of the many means employed to these ends may be mentioned here: the Transactions, the Journal, sections, branches, national conventions, regional conventions, technical and other committee work, etc., etc. It is believed that the Institute has always been as effective in carrying out these three principles as its resources would permit and has, in general, been notably successful in the accomplishment of the first two.

In recent years, with increasing resources, there has come to be realized with greater understanding the importance of the third element, namely,—"the development of the individual engineer." In recognition of this fact, we have our improved district, section and branch organizations, regional conventions, etc.,—all movements in the direction of carrying the Institute life and support as a national organization to sections or branches within a reasonable radius of the individual wherever he may be located.

The result of this effort on the part of the Institute to go to the individual member is indicated in the annual report of the sections and branches presented at the Summer Convention at Swampscott, which all should read in order to appreciate the scope of this movement.* This line of action must be further emphasized in order fully to achieve its important function in "the development of the individual engineer."

It requires *experience* in the activities of a professional organization for any person to adjust himself to that body so that he can fulfil his obligation to his profession through his contributory endeavor, and, in turn, assure for himself that valuable personal development and benefit which should be his. First, come personal friendship and broader acquaintanceship among his fellows. Second, come that professional contact, breadth of understanding, both human and technical, and recognition which are sure to follow honest effort in these directions. It is for each man to avail himself of, or create, opportunity for such service. He owes it to himself as well as to the Institute.

Harold B. Smith

President

**See "Section and Branch Activities," page 647.*

Some Leaders of the A. I. E. E.

Paul Milton Downing, Vice-President in Charge of Electric Construction and Operation for the Pacific Gas & Electric Company, San Francisco, California, and Vice-President of the Institute 1925-1927, was born in Newark, Missouri. He was graduated from grammar school in 1889 and in 1891 had the degree of B. S. conferred upon him by Washington College. Thereafter he entered Stanford University, from which he was graduated with the degrees of A. B. and E. E. in the pioneer class of 1895. During his college career he was active in athletics being one of the football team all four of his college years, and captain of the team in 1894, with Herbert Hoover as treasurer. He was active also on the baseball nine. His interest in the affairs of the University is still keen as President of the Stanford Alumni Association—an office which he has held for three consecutive terms ending with the current year.

After graduating from college, Mr. Downing was employed at first by the Tacoma Light & Power Company, Tacoma, Washington, as dynamo tender; then in 1896 he left this concern to better his position by becoming Assistant Motor Inspector and Powerhouse Operator of the Market Street Railway Company of San Francisco. In 1897 the Blue Lakes Water Company began the operation of the old powerhouse at Blue Lakes City, California, and the promoters offered him the position of Station Superintendent, which he accepted. This was one of the first hydroelectric plants operated in California, and had an installed capacity of 1800 kw., operating at 10,000 volts stepped-up from a generated voltage of 2300.

In 1898 he became associated with John Martin, agent for the Stanley Electric Manufacturing Company, and installed the hydro plant for the Tuolumne Light and Power Company.

In 1900 he became Chief Electrician for the Standard Consolidated Mining Co. at Bodie, California.

On August 15, 1901 he went with the Colusa Gas and Electric Company, for which he installed the electric distribution system, rebuilt the gas works, and managed both branches of the business.

In 1902 he was made Division Superintendent of the Bay Counties Power Company at San Francisco, and in 1903 the California Gas and Electric Corporation and its successor, the Pacific Gas and Electric Company, which was a merger of a number of affiliated companies including the Colusa Gas and Electric Company and the Bay Counties Power Company made him its Superintendent of Substations and Operating Engineer. Later, in 1908, he became Engineer of Operation and Maintenance, and in 1917 was appointed Chief Engineer of the Electric Department.

In 1920 he was made a Vice-President of the company, in charge of electrical operation, and shortly thereafter was given the title of Vice-President in Charge of Electrical Construction and Operation, which is the office he now holds.

In this capacity he had direct charge of the construction of the Pit No. 1 and No. 3 plants, (together with the tunnels and diversion dams), and the Pit No. 4 dam; also the 220-kv-a. transmission tower lines from the Pit Plants to the Vaca-Dixon Substation, one of the first operated at that voltage.

Powerhouse capacity of approximately 285,000 kw. has been installed under his direction, and at the present time he is actively prosecuting work on the 330-ft. high rock-fill dam at Salt Springs on the Mokelumne River, which, when completed, will be the largest structure of its kind in the world. The dam, with the proposed powerhouses, canals, and transmission lines, will involve an expenditure of over $36,000,000.

In addition to the hydroelectric developments of the Pacific Gas and Electric Company, Mr. Downing has charge of the steam-electric stations, and has just completed the installation of a modern high-pressure unit of 37,500 kw., with boilers in Station "C," (Oakland). He is now preparing to install in Station "A," (San Francisco), two 50,000-kw. units with boilers to operate on 1400-lb. pressure. Mr. Downing is also in charge of all the steam heating, water distribution and railway properties of his company.

At the convention of the Pacific Coast Electrical Association, in Pasadena, June 1928, he was elected President of the Association for the ensuing year.

He joined the Institute in 1898 and during 1927 was its Vice-President for the Eighth District.

Mr. Downing is the author of a number of papers relating to the electrical industry. He was appointed to a Conference Committee on Proposed State Legislation on the Supervision of Dams and took an important part in framing the proposed bill for the California State Legislature in 1929.

He is a member of the Permanent Committee of the World's Engineering Congress, of the U. S. Chamber of Commerce, the San Francisco Chamber of Commerce, and of several civic organizations. He is also a member of the San Francisco Industrial Association.

Constructing and equipping of the Harris J. Ryan High-Voltage Laboratory at Stanford University in 1928 at a cost of approximately $400,000.00 was made possible by donations of money and apparatus from the electric power interests of the State; as Chairman of the Committee for interesting the electrical industry and securing donations, Mr. Downing, by personally placing the matter before those whom he thought would be directly or indirectly benefited succeeded in getting a whole-hearted and generous response within a very short time.

Development of Insulating Oils

BY C. E. SKINNER[1]

Fellow, A. I. E. E.

THE integrity of modern transformers and circuit breakers, which are essential features of all transmission systems, is due in no little measure to the insulating oil now universally used in such apparatus. While the oil is a relatively minor part of these devices as a whole, its failure will mean the failure of the apparatus. This is increasingly true as the voltage of the transmission systems is increased. The service rendered by the oil used as an insulating medium in electrical apparatus, is radically different from service rendered by oil in any other class of service and there are rigid requirements for oil for this service which do not exist where oil is used for other purposes. In fact, insulating oil may be considered a material of construction rather than a material of maintenance.

The history of the development of transformer oil begins with the first high-voltage transmission lines in the early '90s, and a continuing and increasing amount of research has been required from that day to this to meet the ever increasing demands for quality and service. The electrical manufacturers' representatives who have been responsible for the quality of the oil used in transformers, have faced many difficulties and have experienced much grief from time to time, due to troubles for which the oil was either directly or indirectly responsible. The fact that such difficulties are rare at the present time does not indicate that further attention to this important material is unnecessary, but on the other hand, it does indicate that a full knowledge of the difficulties which have been so disturbing in the past and a constant watchfulness have mitigated these difficulties to a point where the modern transformer gives perhaps less trouble than any other piece of apparatus in the transmission system.

It may be useful to review some of the history of the development of modern insulating oil and to indicate some of the problems still unsolved, so that a full appreciation by those responsible for the purchase and use of transformer oil may be had. This history may be divided into various chapters, each concerned with the items which seemed to be the cause of the major difficulty prevailing at each particular stage of the development.

When the study was made of oil which might possibly be suitable for the insulating and cooling of the transformers to be used on the Pomona transmission line, this being the first constant high-potential transmission line undertaken in the United States, the study included oils of a very wide variety. Mineral oils, from the heaviest cylinder oil to the equivalent of gasoline and benzine, were carefully studied. Similar tests were made of quite a number of vegetable oils, such as linseed, rosin oil, etc. These early tests were almost entirely on the basis of the determination of dielectric strength. In making these studies, glass containers were used, with the testing electrodes immersed in the oil in a horizontal position. It was observed that any foreign matter visible to the naked eye would line up between the testing electrode and materially reduce the dielectric strength upon the application of the testing voltage, and this at once showed the necessity for extreme care in keeping oil free from foreign matter, such as dirt, fibers, carbonized oil, etc. The necessity for cleanliness has been emphasized again and again with each major increased step in transmission voltages.

In these same tests it was discovered that oil which had been heated in an oven for a considerable period had a much higher dielectric strength than the average oil delivered from the oil manufacturer. There is, of course, the age old tradition that oil and water will not mix, but there seemed no possible explanation for this increased dielectric value of the oil other than that it was due to the elimination of moisture, and that oil was subject to the same difficulties in this regard as most of the other materials of insulation, which at that time had already begun to be studied in considerable detail.

To test the theory, (which from the ancient tradition seemed more or less absurd) that moisture was responsible for the low dielectric value of many oils as delivered, and their changed value on continued heating, the following test was made:

Extremely small amount of water in increasing quantities was added, each addition being a fraction of a drop per gallon of oil, the oil being very thoroughly agitated after each addition. This gave undoubted evidence that very minute amounts of water in the oil would cause radically decreased dielectric strength. This has been checked again and again during the intervening 35 years and more drastic precautions have been found necessary from time to time as the voltage of transformers has been increased. In fact, it has been found necessary to go to the precaution of treating, not only insulation of the transformer to eliminate moisture, but the whole structure, iron-core frame, etc., and to see that the oil which is introduced, especially in transformers for the higher tension is, as we now say, absolutely dry.

The method of drying oil in the early stages of the transformer oil development was accomplished by giving it an extended heating at moderate temperature; but, it was later found that although the temperatures

1. Asst. Director of Engineering, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

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used were relatively low, sufficient oxidation might be started to affect the endurance of the oil against sludging in service. This lead to an investigation of other methods of drying and cleaning the oil, and this is now accomplished by various filtering and centrifuge processes. The requirement is that all suspended matter and all traces of moisture be removed. This is a difficult matter, due to the fact that while the ordinary refining process results in practical elimination of all free water the final moisture to be removed is apparently in solution in the oil.

In the early construction of transformers, the enclosing cases were frequently made of thin material with deep corrugations and with wooden tops, these wooden tops being used for giving added insulation to the outgoing leads. After experience with a number of disastrous fires with constructions of this kind, the underwriters demanded oil having the highest possible flash and fire test, consistent with satisfactory transformer operation. As a result of this requirement, new studies were made and heavier bodied oils adopted. At the same time, attention was given to a better mechanical structure for the transformer cases. The use of this heavier oil resulted in more sluggish circulation and consequently poorer cooling, and apparently little or no decrease in the fire hazard so far as the oil itself was concerned. Soon after this change was made, a new and unexpected phenomenon appeared and this phenomenon is now generally denominated as sludging. This has been perhaps the most difficult matter to deal with that has arisen in connection with transformer oil.

It was soon discovered that a lighter and more fluid oil was in general less subject to sludging than the heavier oils adopted to minimize the fire hazard; but the adoption of these lighter oils merely minimized and did not cure the sludging trouble. As the units became larger and service more difficult, the sludging trouble increased to a point where transformer manufacturers and users found themselves in more or less continual trouble, and very extended studies were made to determine the cause and cure of sludging.

To date, however, no oil has been found which will not deposit sludge if the conditions of its use are sufficiently severe. By very careful selection and by eternal vigilance on the part of the oil refiners and the transformer manufacturers, oil has been produced which under all modern operating conditions is sufficiently free from sludge to give satisfactory service.

Unfortunately, no test has yet been devised which will quickly determine whether or not oil will be free from sludging in service, although an enormous amount of experimental work has been done and many tests have been proposed and used. This question has been considered of sufficient importance to warrant the cooperation of all the nations interested in the production and use of transformer oil to determine, if possible, a satisfactory sludging test. For this purpose, and working through the International Electrotechnical Commission, duplicate samples of oil have been submitted to laboratories of half a dozen or more countries and extensive tests have been entered into for this purpose. At the meeting of the International Electrotechnical Commission in Bellagio, Italy, in October 1927, the report of the various committees and laboratories which have been working on this question for two or three years, was to the effect that the various tests were conflicting in that one test might indicate that a given oil was satisfactory, while another test just as strongly defended, might indicate this oil to be unsatisfactory.

The result of this meeting showed that additional work must be done in order to determine which of the half dozen methods now more or less used would be the satisfactory one to evaluate oil with regard to its sludging characteristics, or whether an entirely new test must be devised. To date, the only safe procedure which has been found has been that of very careful laboratory tests combined with extended service tests, in many cases of several years, to bring the assurance that oil used would show a minimum of sludging troubles.

In the meantime, the oil refiners and transformer manufacturers, and some of the users of transformers, have been making continual studies, both as to the cause and elimination of sludging troubles, and for the securing of oil that would be free from this trouble and would meet all of the other rigid requirements for transformer oil to be used with the highest voltages.

Through a pure accident, discovery was made fairly early in the study of insulating oil to the effect that free sulphur would very greatly impair its insulating value and much study was given at one time to the effect of both free and combined sulphur in minute quantities in insulating oil. In like manner, the residual acids from the refinery treating and other effects of processing the oil, had to be studied with each change in the refining process to bring about the various characteristics necessary to meet the increasingly exacting requirements on this material.

The manufacturers of apparatus using insulating oils, early found it necessary to establish intimate working relations with the oil refiners and as they were required to meet one requirement after another, the refiners developed a special procedure from the selection of crudes in the fields through the final manufacturing process. The characteristics governing selection at the wells include such items as pour point, freedom from wax, amount of sulphur, etc. In some cases special pipe lines are used to transport the crudes selected for the manufacture of insulating oils to the refineries in order that contamination with other crudes shall not occur. During the preparation of the distillate by the vacuum process, rigid inspection for viscosity, flash, and pour point control is maintained and where these oils require treatment with strong sulphuric acid or equivalent, special care is required to see that there is complete neutralization and thorough washing of the oil, and this treatment is sometimes followed by re-

distillation in order to remove all traces of reaction products remaining after washing.

The advent of outdoor transformer and switching stations imposed an entirely new requirement on transformer and switch oil, namely, the necessity of a very low congealing temperature, or as commonly known, a low-cold test. Transformer oils which were found relatively satisfactory for the old indoor stations had a relatively high-cold test and consequently were not satisfactory for outdoor stations, particularly in cold climates. This requirement for a low congealing temperature is even more rigid in connection with oil switches, which must be free to operate at any temperature which may be reached in the climate where an outdoor switch may be installed.

This requirement for low-cold test oil demanded a whole new series of studies, as the general requirements for indoor apparatus, such as freedom from dirt, moisture, and relative freedom from sludging, etc., had to be maintained. In all such studies it had to be kept in mind that there was a constantly increasing demand for oil and that any oil selected must be available in sufficient quantity to supply this demand. Fortunately, oil has been developed through the cooperation of the oil refiners and transformer manufacturers, which meets the previous requirements, as well or better than any which had been previously used and which has a sufficiently low-cold test to be satisfactory for all ordinary outdoor service.

From almost the beginning of the development of oil for cooling and insulating apparatus, mainly transformer and circuit breakers, the transformer and circuit breaker requirements seemed to be sufficiently divergent so that no single oil would be satisfactory for both services. Certain characteristics of these two services are in opposition to each other, while certain other desirable characteristics coincide. For example, all the early tests and service experience seemed to indicate that the circuit breaker required a relatively heavy and sluggish oil, while the transformer required as light an oil as possible, in order that it might have sufficient fluidity under all conditions to circulate rapidly and transfer the heat from the transformer windings and core to the outer cooling surface. Again, an enormous amount of experimental work was necessary to find an oil which would meet both these services sufficiently well so that utilities would not be required to carry two or three grades of transformer oil and one or more grades of circuit breaker oil. Several years of laboratory and field tests were carried on before there was sufficient confidence on the part of the electrical manufacturers to justify their making a positive assertion that an oil was available in quantity which had all the necessary requirements sufficiently well fulfilled to justify the stand, that this oil could be used as a universal oil for all insulating and cooling work in transformers and circuit breakers.

It has been found that the balance between the two services is very close, and that continued experimental work and the closest possible inspection and testing of oil of this class must be followed in order that the necessary characteristics may be maintained, suitable for all services and for all climates. The advantages of universal oil are so obvious that no arguments are necessary to justify its use.

Throughout the whole history of the development of oil for insulating purposes the question of shipping containers and storage arrangements has been found to be of the utmost importance. In the early days oil was shipped in wooden barrels which were made tight by the use of ordinary glue. This led to interminable trouble from the glue getting into the transformers and other devices, helping to reduce the dielectric strength and to increase the sludging characteristics. Seepage of the oil and the entrance of moisture were common difficulties with such containers.

With the introduction of steel drums, a new kind of trouble developed. Additional dirt and scale was introduced into the oil and it was soon found that the more rigid cleaning and inspection methods did not always eliminate such difficulties. When the use of oil arrived at a point where tank car shipments were necessary, still further difficulties (dirt and water) appeared. It was not at all uncommon in the early days to find a considerable quantity of water in the bottoms of the tank cars containing transformer oil. Condensation of moisture, both on the exposed surfaces of the tank cars and on the surface of the oil itself, were almost inevitable and imperfectly protected openings frequently resulted in additional trouble.

It had been assumed that steel drums with continuous lead washers under the bungs, would be both proof against seepage and proof against entrance of moisture, but this was found not to be the case, and the writer of these notes is familiar with a considerable number of cases where drums of oil, with bung-up exposed to the weather, were found to contain a considerable quantity of water, when it was absolutely certain that these drums were moisture free on shipment. This was apparently brought about by the heating and cooling of the oil due to the changes in temperatures, between day and night, the resulting pressure and vacuum helping the entrance of water at the bung when this would be covered by rain water.

The oil refiner has accomplished, therefore, only a part of his necessary functions when he has prepared the proper grades of oil. These must be so handled after preparation as to deliver them in the cleanest possible condition to the ultimate consumer. Amounts of contamination which would be inconsequential in lubricating oils will cause no end of trouble in transformer oils, so that an entirely new scheme of preparation of packages and lines of special containers have been found necessary. Every container returned to the refiner must be most carefully inspected and put in such condition that it will not cause any of this con-

tamination. The removal of rust and traces of foreign materials which have been stored in the containers, and every other kind of contamination must be absolutely removed, or the container is rejected and many rejections occur in the inspection of such returned containers. The time between the final cleaning and inspection of containers, and the time of filling with the transformer oil and sealing must be an absolute minimum.

Even with all the possible precautions taken, the practise of making individual inspection of oil in drums after allowing a suitable time for foreign matters to collect at the bottom, has been found essential.

There is, of course, involved the shipment of small packages ranging in volume from one to five gallons. Disastrous experiences were run into through the use of ordinary "run of mill" tin cans in the early stages of the business. It later developed that the cause of this was the use of packages, the seams of which had been soldered with acid flux and the latter material had worked into the cans with harmful results to the dielectric strength of the oil which the packages contained. This has resulted in oil refiners installing a special line of machinery for the manufacture of these containers under such control as to insure against the possibility of their becoming contaminated with materials which cause harm to the oil. Not only must these containers be manufactured properly, but they likewise must be tested for leakage and suitably dried before filling, after which they must be immediately capped with the specially designed fittings which have been brought out for this purpose only. Furthermore, it is necessary that inspection be made of a certain portion of the tin containers in order to insure that the quantity of the oil ready for shipment in these packages is running uniformly satisfactory.

During a few months of the year, under carefully controlled conditions, insulating oils of good dielectric strength could be delivered in ordinary tank cars but because of the extreme difficulty of properly drying them before filling, it is unsafe to guarantee deliveries in these tanks at all seasons. As a result of this condition, special cars have been developed with steam coils surrounding the shell, these coils in turn being protected by wooden jackets covered and protected with heat insulating material and thin sheet iron. Only with such equipment as this has it been found possible to properly dry out the cars before filling to such an extent that delivery of dry oil at destination can be assured. With these cars it is possible to not only dry them out before filling is started but during this operation to maintain the temperature of the cars at such a figure as to assure freedom from contamination of moisture in the oil in the cars before the filling is completed and the cars sealed.

A specific example, involving serious difficulty, will be of interest. Serious operating trouble was experienced with some high-voltage circuit breakers, each containing over 3000 gallons of oil. The oil in this particular case was not the standard usually supplied by the manufacturer. As a result of the difficulty the oil had to be completely replaced in an outdoor installation in severe weather, and in the final investigation the trouble was traced to faulty manufacture of the oil and to sloppy methods in its handling.

It was early seen that some sort of cleaning and drying apparatus was essential in connection with the use of oil in some quantity as is required in the average power transmission station. Various schemes of filtering, drying, and cleaning oil have been devised. These included filtering through paper, unslaked lime and the application of heat and various other schemes. The plan which seems to give the best all-round results and is now quite generally used, is that of the use of a centrifuge type of cleaning device, often combined with a pressure filter. Extensive research work in connection with the universal oil referred to above, has shown that both the transformer and switch oil often may be reconditioned after it has become contaminated, to a point where it is unsatisfactory for use. Apparatus for this purpose is now manufactured and very specific instructions have been worked out for the use of this apparatus in reconditioning and for the testing of reconditioned oil.

Parallel to the research work on the oil itself, many improvements have been made in transformer and circuit breaker designs to aid in eliminating the difficulties encountered in connection with the oil problem. It was early proved through research work that exposure of oil to the air very greatly increased its tendency to sludge and that this increase with a given exposure was more or less a function of the temperature of the oil. This led to transformer case designs, which included the conservator type of case and more recently, the inertair scheme, which automatically provides in service for the elimination of both moisture and oxygen from contact with the oil in the transformer. While these devices have not changed the tendency of the oil to sludge under a given set of conditions, they have aided very greatly in changing service conditions, thereby inhibiting sludging and maintaining oil in a clean and dry condition.

The final result of all this work, which has extended over a period of more than 35 years, has been to make the modern transformer and circuit breaker with the universal oil, among the most satisfactory devices which goes into the modern equipment for the production, transmission, and utilization of electrical energy. The transformer and circuit breaker manufacturers, together with the oil producers who have brought about these results, realize that only eternal vigilance and continued research will make it possible to maintain and better the conditions which have been arrived at after so much labor and research in the past.

Population as an Index to Electrical Development

BY N. B. HINSON[1]
Member, A. I. E. E.

IN making plans for the future in the electrical utility business it is necessary to make estimates of future growth. Various methods have been used. The usual method is to plot growth of one kind or another against time. This gives an upward curve which is difficult to project mathematically and usually is misleading if projected ahead more than two or three years in a rapidly growing territory. In the electrical utility field various values have been plotted against the number of consumers or meters. This is all right for past data but for the future the number of meters or consumers would have to be estimated and this would depend upon the increase in population, especially if all the present population now had service.

This led to the use of population as the abscissa rather than time or consumers with any of the values desired as ordinates. This gives a straight line for practically all present values and the future is a straight line projection with a simple formula. The lower end of the line does not usually cross both zero points and this fact gives the changing values per unit of population.

The various values at the very beginning of the industry do not give the correct trend as only a small number of people had service, but the business is now and has been for the last ten or fifteen years developing very uniformly and consistently and these later values give the correct past trend.

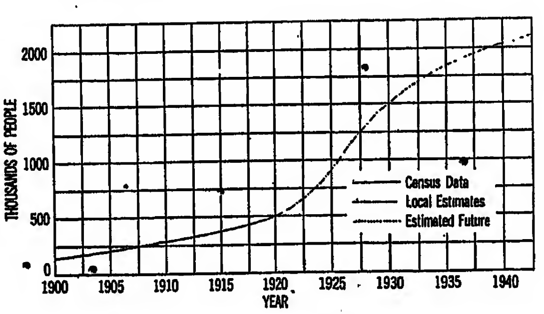

FIG. 1—POPULATION SERVED DIRECT BY SOUTHERN CALIFORNIA EDISON CO.

Population for the past, at least up to the last census date for any city, town, or county, is easy to obtain and in many locations accurate estimates up to 1928 are available. However, when it comes to projecting these values for ten or fifteen years into the future quite a problem arises, particularly in rapidly growing territory such as is found in numerous locations in the United States.

Raymond Pearl in his book, "Studies in Human Biology" has developed a theory of population growth which gives a curve of population for various cities and countries that describes past growth with great precision and fidelity, and predicts future growth in a more satisfactory manner than the usual method of projecting ahead with the same percentage increase as the place under consideration has had for a number of years back. This type of curve Mr. Pearl calls the "Logistic" type curve though it has come to be known in our territory as the "Fly Curve" from one of the experiments he performed and describes in an article entitled the "Biology of Population Increase."

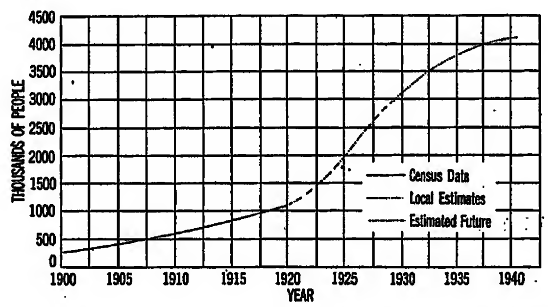

FIG. 2—TOTAL POPULATION SERVED BY SOUTHERN CALIFORNIA EDISON CO.—INCLUDING WHOLESALE

The population curves used for the territory which will be described were compiled from the census data for 1900, 1910, and 1920, and from estimated values of various Chambers of Commerce, Local and State Officials, Statistical Bureaus, etc., for the years 1921 to 1928. These curves were then projected ahead from the known data, the rate of growth, according to Mr. Pearl's conclusions, decreasing as the saturation point is approached. See Figs. 1 and 2.

The system on which these studies have been made is that of the Southern California Edison Company serving in Central and Southern California. Southern California, in which most of the small towns and cities are located, is one of the fastest growing communities in America. More than 99 per cent of all the houses in the territory covered have electric service and this value has been more than 90 per cent for ten years. Also the Southern California Edison Company supplies 62 per cent of the total kilowatt-hours direct to their own retail consumers, and 38 per cent wholesale to other companies and cities for redistribution and to the railways.

1. Southern California Edison Co., Los Angeles, Calif.

Presented at Pacific Coast Convention of the A. I. E. E., Santa Monica, Calif., September 3-6, 1929. Printed complete herein.

In considering gross revenue, kilowatt-hours generated, and kilowatt peak, the total population in the territory served direct and indirect were used, and for horsepower connected, number of meters, and system betterment budget, the population served direct was used. These are illustrated in Figs. 3 and 4.

As will be seen, the population served is plotted uniformly and the date at which so many people were in the territory, or it is estimated from the population curve will be in the territory, is set opposite that number of people. The values of kilowatt-hours or horsepower or whatever is being plotted are set opposite the year in which they occurred. These points lie in such a position that in all cases a straight line can be drawn through the group, and this line projected ahead gives values for the future.

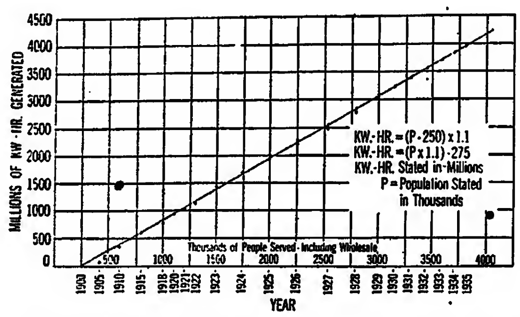

FIG. 3—TOTAL KW-HR. GENERATED YEARLY—UNIFORM POPULATION

Since the values for the future are dependent on population which is an estimation, such future values for more than five years are liable to be in considerable error, but it supplies a means of getting values which can be calculated and is much better than projecting curves which are changing their shape from year to year. Figs. 5 and 6 illustrate the same data plotted against time. This will illustrate the difference in the two methods. Also as additional data are available such as the census for 1930, the population curve may change but it is only necessary to move the date to its correct position on the various studies. In other words, the straight line values are such that they show the value when there is a given number of people, irrespective of the date on which it occurs.

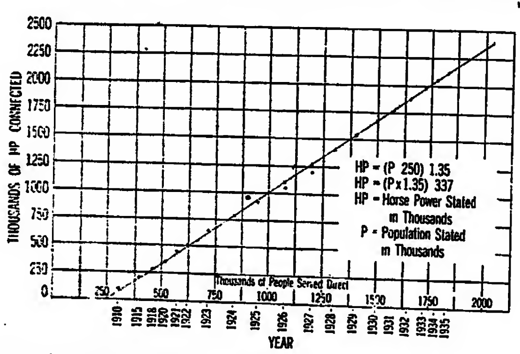

FIG. 4—TOTAL RETAIL HP. CONNECTED—UNIFORM POPULATION

The foregoing are all with regard to the system in general and assist in forecasting so far as generation and transmission are concerned. A study was made of the load on small stations supplying cities and towns so as to be able to forecast the transformer capacity necessary in the future, particularly when new stations are contemplated so as to install transformers that will not have to be changed within a year or two.

These studies were started on a load density basis of kv-a. per square mile. These studies were made on ninety cities and towns in Southern California, ranging from 1500 to 150,000 in population, the average being 10,000. The original study was made in 1925. This same study was made for the year 1928, using seventy cities which are incorporated, and on which it is possible to get a fairly accurate estimate at this time of population.

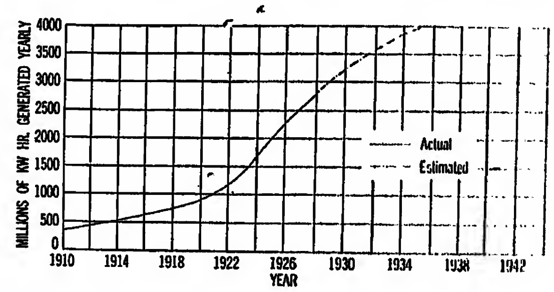

FIG. 5—TOTAL KW-HR. GENERATED YEARLY—UNIFORM TIME

The maximum kv-a. demand for the year 1928 was used and the area in square miles of the developed territory, that is the territory actually built up including all vacant lots. This gave a value of kv-a. demand per square mile which varied from 270 to 2700. There seemed no logical relation between areas so the population for each city was taken and the cities grouped according to size, that is average values for all cities 1000 to 5000, 6000 to 10,000, 11,000 to 21,000, 21,000 to 30,000, 31,000 to 40,000, and 41,000 to 150,000, the last group including only five cities.

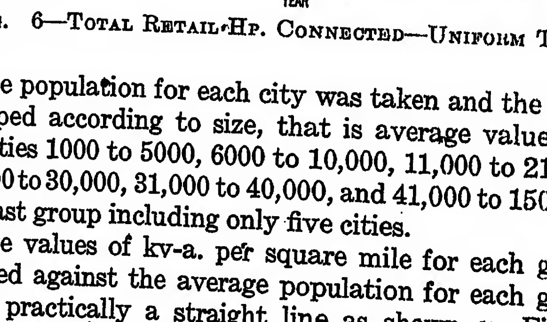

FIG. 6—TOTAL RETAIL HP. CONNECTED—UNIFORM TIME

The values of kv-a. per square mile for each group plotted against the average population for each group gave practically a straight line as shown on Fig. 7. Spotting all seventy of the cities shows how close they follow the average. This gives a simple formula for kv-a. per square mile for various sized cities and this

times the developed area in square miles give the peak demand. This has been applied to several cities for which the data are available for five or ten years in the past and they check very satisfactorily. These apply only to a unit city; if two cities have combined and each had its own business district the combined city will give values of kv-a. per square mile that are too high, that is a city of 25,000 people developed as a unit has a greater load density per square mile than two cities each of 12,500 combined as one city. This system of future peak load projection has been used to set up the probable demand for all cities five years in the future. There has been some increase in the kv-a. demand per square mile during the last three years for any sized city so that it will be necessary to check these data again after the 1930 census. However, it gives a fairly accurate check on the probable future demands.

Fig. 8 shows the peak demand of the various cities plotted against the population. This value has been increasing yearly due to the increased use per capita of electric energy; it was 110 kv-a. per 1000 people in 1920, 125 in 1925, and 150 in 1928. For the smaller cities the peak demand is higher due to less diversity of load. This is also seen in the kv-a. per square mile being lower for the smaller cities as the development is not as uniform as the larger cities.

For making forecasts for the future no hard and fast rules will apply and all these means are used to check from as many angles as possible the future value. The

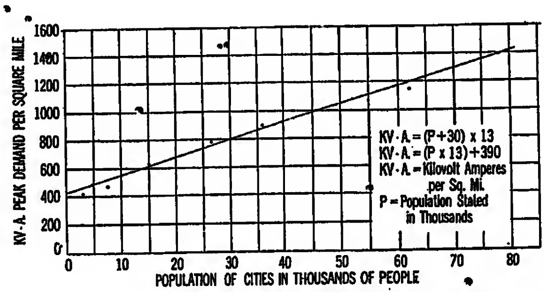

FIG. 7—KV-A. PEAK DEMAND PER SQUARE MILE—GROUP AVERAGES OF 70 CITIES

regular daily and monthly peak load readings on each station which have been kept for a number of years can be projected ahead as a check on future loads.

The distribution system is divided into thirty-two districts with an average of 13,000 customers, the minimum being 3000 and the maximum 50,000. Each of these districts has separate records and is set up similar to a small company. Any data that check up satisfactorily for all the districts may be used for the system. From these data yearly, average values of people per meter, per distribution transformer, per distribution transformer kv-a. rating, per pole, per mile of line, per substation, kv-a. capacity, per substation peak kv-a., per kw-hr. per year consumed can be determined. These values change from year to year but only slightly and these changes can be determined.

These data would not be the same in various parts of the country as the saturation is different and the character of the territory is different. Such values worked out for a particular territory enable fairly accurate estimates to be made of many of the factors entering into its electric utility business. In a territory in which practically every house has electrical service and has had for a period of approximately ten years, the various factors are perhaps more nearly related to the number of people in the city or territory.

This system of using population as a means of determining values of electrical development has been of

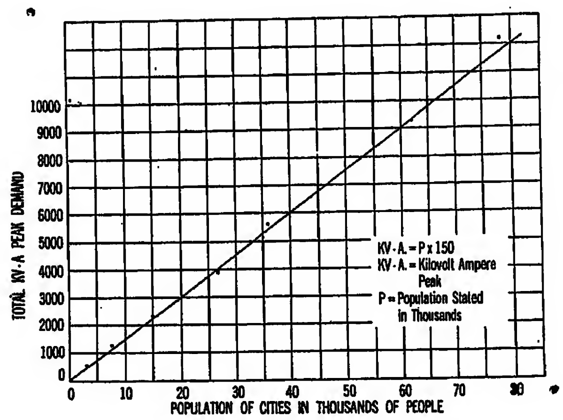

FIG. 8—TOTAL KV-A. PEAK DEMAND OF CITIES—GROUP AVERAGES OF 70 CITIES

great assistance in a rapidly growing territory and has enabled the mathematical determination of values in the future which otherwise would be pure guess work.

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Automatic Stations

ANNUAL REPORT OF COMMITTEE ON AUTOMATIC STATIONS*

To the Board of Directors:

Introduction

This terminates the second year of the existence of this committee. The field of action in which this relatively new committee finds itself is so broad and has so many inviting by-ways that it has been difficult to outline the work. The engineering in connection with the application of automatic control is so fascinating as to result in so many new ideas being steadily developed that the fundamentals are sometimes almost overlooked. It is indeed amazing to realize the changes in ideas which occur in this branch of the industry in a single year. This committee attempts in the following report to outline some of the development and offer suggestions which are intended to benefit this branch of the industry.

Scope

The scope of work of this committee covers automatic and partially automatic generating stations and substations, the committee having complete jurisdiction over all apparatus associated with such stations. In addition the committee has jurisdiction over systems of remote dispatching, control, indications, etc., associated with the industry. The committee is interested in the dissemination of the knowledge and experience already gained in the design and operation of such equipment and combinations thereof, in order that this branch of the industry may be more fully developed.

Economical Construction

The developments of the year indicate a general tendency to take advantage of the economical construction possible with the use of automatic stations. It is still hard to realize the radical difference in station arrangement and set-up between the old firmly rooted manual system of operation and modern automatic operation. We are beginning to see, however, that the presence of a human mind and body in the manual station had a marked effect on station arrangement and that mechanical and electrical things were done solely because of the safety, comfort, and convenience of this human presence. Automatic control has all but eliminated this human body and has moved the mind from the station to the office of the engineer.

It is believed that one of the most radical and economical changes in station arrangement has been the elimination of the continuous switchboard. When this is studied it is found that there is no longer a necessity for assembling all of the control wiring from remote parts of a station at one point at the expense of thousands of feet of wire and conduit just to produce a switchboard assembly that makes a nice appearance.

The above is particularly true in a-c. substations and hydro-station applications where the details of control can and properly should be located as near the equipment controlled as is consistent with good fire protection and safety. It is now becoming common to see control panels located in various places throughout a station close to the equipment controlled, thus saving considerable in wire, conduit, and hazard.

Another saving has been realized from the reduction in size and in some cases the complete elimination of heating plants.

Ventilation has also been reduced, as in many cases a considerable amount of air was required over and above that actually required by the station apparatus for the comfort of the operating employes.

The problem of station location has been eased somewhat by the advent of automatic control as stations can now be located in places where it would be almost impossible to keep operating men on the job on account of the absence of what might be considered the proper amount of daylight, pure air, water, etc., necessary for the continuous maintenance of human beings.

Research and Development

Research during the past year has brought forward many improvements in detail apparatus which are contributing much to simplify the problems of application. Careful analysis of operating records disclosed the need of more simple means for the adjustment of

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L. D. Bale,	Joseph Hellenthal,	Roy M. Stanley,
C. A. Butcher,	Chester Lichtenberg,	L. J. Turley,
M. S. Coover,	S. J. Lisberger,	F. Zogbaum.
	G. H. Middlemiss,	

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equipment to meet a wide range of applications, particularly for the calibration of relays. Much has been done in this connection with the result that not only have improvements in relays simplified matters of calibration but by extending the range of application, the number of types of relays required has been reduced, thus greatly simplifying routine inspection and maintenance.

Simplified and improved supervisory control and remote metering systems have been produced as a result of experience with several very successful schemes in numerous applications.

Some work has been done in the development of devices for recording operations, quantities, etc., on charts, but this appears to be one of the weakest points in automatic development. There are devices available for recording almost anything desired but either they are insufficiently reliable or their cost is prohibitive for extensive applications.

Simplified schemes of control for the automatic switching of rotating apparatus looking toward reduction in the number of moving parts are being tried out. The economics of application are being given a great deal of study. On a number of metropolitan street railway properties, the items of power consumption from the generating stations to the car wheels are being carefully analyzed. Operating voltages best suited to given operating areas will be selected and means for automatically or remotely controlling the substation apparatus for proper adjustment of the voltage to operating conditions will be provided.

Operators and careful analysis of operating results are the sources of information which will enable the manufacturers to develop new and improved equipment and to this end, it is urged that systematic and well-kept records be made available on operation, inspection, and maintenance. Well operated stations are the proving grounds and as essential to progress as the laboratory.

Operating Reports and Inspection

The predecessors of this committee have stated that the art would advance much more rapidly if more operating engineers would avail themselves of the opportunity at Institute meetings to tell of their individual experiences, through papers and taking part freely in discussion. Your present committee wishes to emphasize this and add an invitation to correspond freely with the members of this committee on subjects of interest to the followers of the automatic art. It is felt that in this way the annual reports of this committee will be made more representative. With this idea in mind your committee has this year sent out questionnaires attempting to gather operating, maintenance, and inspection data from a wide field of experience, covering a variety of applications. While these questionnaires may be considered a burden by some, this committee feels that a great many engineers are vitally interested in the subject and are willing to furnish the data requested to the end that the art may be more universally applied and incidentally improved. Some answers to the questionnaire have been received but not sufficient to present a recapitulation in the pages of this report. This committee intends to turn this partly finished work over to its successors with the earnest recommendation that they carry it forward.

Inspection and maintenance of automatic plants may be catalogued into two general classifications, equality and quantity, depending entirely upon the continuity of service expected and demanded of the automatic plants, and by the individual managements.

The word "maintenance" is used advisedly in view of the fact that inspection and maintenance are so closely allied at times as to be almost inseparable.

The old phrase, "getting out of a thing what you put into it" is exemplified in automatic station operation. However, the curve of failures of equipment to function plotted against dollars spent on inspection and maintenance, is not at all uniform, cost ratio increasing much more rapidly as the number of failures declines to the zero point. This point is clearly illustrated by a member of the subcommittee, and a pioneer in the automatic operation of a large metropolitan system, who states that two extremes are possible in automatic substation operation, under inspection and maintenance, and over inspection and maintenance.

A plant may be used for such a test, little or no inspection and maintenance being given during a predetermined period of time, observing the number of failures occurring, with their causes. By taking this number of failures as the unit, one hundred for example, and increasing inspection and maintenance, the failures will diminish rapidly to a point whereby 90 per cent of the one hundred will have been eliminated during an equal time period. At this point, inspection and maintenance can be doubled with the resulting effect of the elimination of only a few of the remaining ten failures. A happy medium between the two extremes is therefore logically assumed the most economical method of operation.

Past and present experience as reported by the various operating engineers, seems to disclose the fact that to function properly, automatic equipment should be given casual and periodical inspections. These inspections vary according to the needs and conditions of the individual installation, and the severity of service. The casual inspections on metropolitan systems as reported, are made as often as two hours apart during the heavy hours of the day, and two or three days apart on other systems and conditions.

These inspections usually consist in observing the functioning of equipment in service, overheated contacts, graphic chart clocks for time, inking, bearings, overheating, ventilation, etc. For stations outside of metropolitan districts, the casual inspections are likewise reported as being made daily on some systems, and weekly on others, ranging in the average of two or three

times a week, with a tendency to make fewer inspections when the stations are equipped with supervisory control. The actual time required to make a casual inspection is much less than the traveling time.

A startling fact was disclosed when only about half of the 23 engineers replying to the questionnaire indicated that they followed any prepared method in inspection and testing but relied upon the field man entirely. It followed that in these cases no form was provided on which the field man could accurately report. Results from such a method must surely vary with the character and temperament of the inspector and cannot possibly be conducive to good operating and service results. Many of the replies, however, indicated the existence of very closely prescribed test and inspection methods along with very complete records including very comprehensive classifications of device failures. That sort of practise, if universal, would most certainly pay dividends to the industry. This year's committee has become so intensely interested in this subject that the thought has occurred to attempt the standardization of test and inspection methods, forms, and failure classifications. It is felt that with standard forms in use this committee could be made a clearing house for much valuable information, thus permitting the designing engineers to profit by the mistakes of others as well as by their own.

In order to implant the thought we are herewith submitting a suggested form.

STANDARD AUTOMATIC SUBSTATION TROUBLE FORM

Date__________19___

__________Station No.______

Device Which Failed________________________________

Machine, Transformer or Circuit Number________________________________

Nature of Failure________________________________

Cause of Failure________________________________

Consequences________________________________

How Remedied________________________________

Located By:______________Repaired By:______________

Unit Out of Service from________M.________To________M.________

What Load Actually Interrupted and for How Long________________________________

What Load Otherwise Affected and for How Long________________________________

√ CLASSIFICATION	Copies to:
☐ Improper Adjustment by Mfg.	____________
☐ Improper Adjustment by Owner.	____________
☐ Improper Application.	____________
☐ Improper Assembly	Approvals:
☐ Improper Design.	____________
☐ Lack of Proper Inspection by Owner.	____________
☐ Defective Workmanship by Owner.	
☐ Defective Workmanship by Mfg.	
☐ Unforeseen Operating Conditions.	
☐ Undetermined.	

By the use of forms similar to the one herewith submitted, several operating companies have been able to detect particular devices, schemes of connection, etc., which persistently give trouble, and as a result have increased the reliability of their equipment to a considerable degree by correcting the troublesome elements. One company in addition to the classification of the failures shown on the form, classifies and records the failures under device numbers and types.

One of the companies sends copies of all trouble forms to the manufacturer of the equipment involved, thereby giving the manufacturer the opportunity to turn the experience into something profitable to both themselves and the user.

Papers

Six papers were presented to the Institute during the year on the general subject of automatic stations and were sponsored by this committee:

Automatic Mercury Arc Power Rectifier Substation on the Los Angeles Railway, by L. J. Turley, Spokane, Aug. 1928.

The Automatic Substation—Its Relation to Electric Distribution Systems, by S. J. Lisberger, Spokane, Aug. 1928.

Telemetering, by Linder, Stewart, Rex, and Fitzgerald, New York, Jan. 1928.

Automatic Mercury Rectifier Substations in Chicago, by A. M. Garrett, Cincinnati, Mar. 1929.

Automatic Reclosing of High-Voltage Circuits, by Robertson and Spurgeon, Dallas, May 1929.

Automatic Transformer Stations of Edison Electric Illuminating Co. of Boston, by W. W. Edson, Swampscott, June 1929.

Standards

Standards for automatic stations (No. 26) were adopted and issued in 1928. It was realized that in view of the rapid progress of this branch of the industry it would be necessary to revise these standards from time to time. A subcommittee has worked out some desirable changes which are not voluminous enough to warrant a revision of the Standards as published. However, this committee will add to this group of changes from time to time, until it is felt that it is worth while to present them to the Standards Committee with recommendations.

Bibliography

With the idea that a complete bibliography of automatic station literature would be of inestimable value to the electrical engineer, this committee published as an appendix to its report last year a complete bibliography up to the date of the report. A supplement covering literature published from the last report to March 1, 1929, is included in the complete report as an appendix. Acknowledgment with thanks is hereby given to the Main Library, General Electric Company, for this service.

"Synchronized at the Load"

A Symposium on New York City 60-Cycle Power System Connections

I. A Fundamental Plan of Power Supply
By A. H. KEHOE

II. Calculations of Systems Performance
By S. B. GRISCOM

III. System Tests and Operating Connections
By H. R. SEARING AND G. R. MILNE

Review of the Subject

Under our modern conditions it has become a common experience to have certain improvements adopted as necessities, although at some earlier time they would have been classed as extreme luxuries. Electrical service rendered by metropolitan public utility companies in recent years has evolved into one of these necessities due to the change in customs and in living conditions of the American people. In the initial stages of development, while the central station industry was taking the preliminary steps to establish itself in the commercial field, its product being expensive was purchased only where it could be indulged in as a luxury. During this period, methods of utilization of electrical service were very limited, being confined almost entirely to illumination. Such electric systems as existed were small, and the problem of their continuity was not of major importance. Disturbance and even interruption to customers' supply was a regrettable but not a vital incident. Cost of energy was the principal consideration rather than the reliability of supply, particularly where strong competition with other established forms of service was to be expected. As the art developed, many efforts were made to improve the quality of service in order to make a more salable product; nevertheless some interruptions were still experienced and were usually considered a necessary evil. With a much improved, but less expensive product, other competing methods of supply gradually became obsolete, leaving the central station alone in its field with an obligation to render the best possible service. Then interruptions could no longer be considered minor incidents.

Service to districts with high-load density, such as the central portion of cities, very soon felt the effect of this requirement, and the demand was usually met by adopting systems of distribution which would give reliable service although at increased expense over other methods of supply, which, while much less costly, could not offer the same degree of reliability. The influence of quality service had its effect on the requirements of these as well as other districts, and the entire elimination of service interruptions has everywhere been given the most serious consideration due to the dependence of the customer on a reliable service that will not cause interruptions resulting in serious inconvenience, economic loss, or possible hazard to life. Also there are many new types of utilization that are constantly being adopted as higher reliability with lower costs makes these available to all. With further reduction in costs, many other new applications are certain to arise. Thus, it follows that low-cost reliable service produces greater utilization which, in turn, makes it imperative to render still better service. This characteristic development is a feature of American life, and its counterpart in some form of material progress will be found to be the basis for most of the changes which have taken place in our modern customs. In the case of metropolitan central station companies, the huge concentrations of power required to provide the services which are a necessity for the normal life, and business of the community, make the problem of reliability of supply at low system costs of vital importance to all.

The papers comprising this symposium present a new principle of decentralization of power sources and cover the investigation of a new plan of design and operation of a metropolitan power system. This arrangement is expected to provide the solution to the problem of reliability of supply and low system costs. The underlying ideas have been verified not only by experiments on one system but also by an extensive engineering analysis. Close agreement was observed between calculated and test results, and this should justify the use of the analytical methods outlined in applying the principles involved to the design of other power systems. The fundamental plan is described and the methods and results of calculations made are given. The symposium concludes with system tests and operating experience with the new arrangement of connections.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929.

"Synchronized at the Load"—I

A Fundamental Plan of Power Supply

BY A. H. KEHOE[1]

Fellow, A. I. E. E.

Synopsis.—The New York 60-cycle system is operating with connections giving parallel paths between generating units only at the load. High values of reactance result for synchronizing circuits between the several generating units, but the usual values are present in the main energy channels between generators and load. Connections are contrasted with two common types of metropolitan power systems; i. e., the "close linked" and "loose linked" systems, and are shown supplemental to multiple-feed network distribution, as the principle of using separate multiple feeds from independent generators connected in parallel only at the load extends the network distribution system to the generating stations. In completely networked distribution, the 120/208-volt mains acting as a short-circuit-proof bus, supply the only synchronizing paths between generators. Substation busses serving radial load are substituted where complete networks do not exist. Calculations, tests, and operating experience indicate synchronizing power sufficient to give stability to all elements of the system not directly affected by a fault. Some advantages derived are: Increased reliability of generating sources, lower interrupting duties on circuit breakers, and reduction in service voltage disturbance.

Connections for Improved System Behavior

The New York City 60-cycle power system is now operating with an arrangement of connection which gives paralleling paths between generating units only at the load. Each generator while in service on this system is described as being "synchronized at the load." This term refers to the conditions under which each unit is maintained in synchronism, but it does not refer necessarily to the initial synchronizing

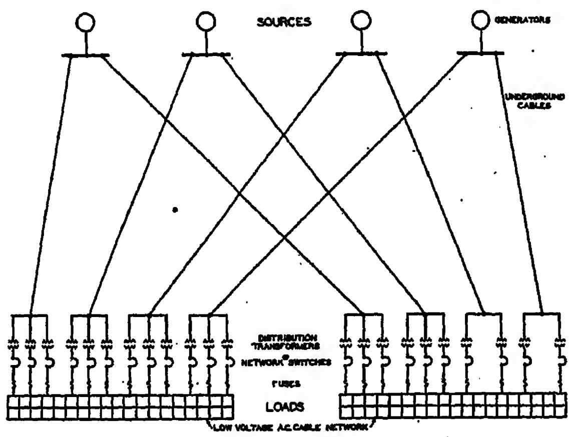

Fig. 1—Schematic Connections for System Synchronized at the Load

of one generator with the rest of the system. Fig. 1 shows a simplified diagram of the arrangement. Such a scheme of connections gives high reactance values for the synchronizing power circuits between the several generating units in comparison to the values which are in general use with generators also synchronized at the station bus. Nevertheless, the main energy channels between generators and the load have reactances, in respect to normal capacity, of the same order as those usually experienced with metropolitan underground cable systems. Thus, while this arrangement does not fundamentally affect the normal power distributing characteristics of the system, it does improve system behavior during abnormal conditions in several ways which are discussed in this and in companion papers.[2]

Typical Power System Arrangements

Ever since d-c. machines were first operated in parallel, or following this when individual drive alternators were first synchronized, the usual arrangement has been to provide for paralleling as near to the sources of power as possible. For a number of years, machine capacities and system reliability have required some means of obtaining increased reactance values to limit fault currents, and many large station busses have been broken up into sections by inserting current-limiting reactors. Generator leads supplying the bus and feeders from the bus in some cases have been similarly equipped. Such busses usually take the form of a closed loop or ring and are composed of a number of sections, each connected to its adjacent sections through reactances. Another scheme in use is the star arrangement, in which each individual bus section is connected through a reactor to one common bus or star point. Since the amount of reactance as well as its location in the circuit can easily be varied, many different plans of bus layout are in use. In general, however, it has become standard practise to parallel generators in a generating station as close to the source as possible by using some plan of either the "ring" or "star" bus arrangement.

Whenever systems are supplied from more than one generating station, it is customary to use either tie feeders between stations to provide an extension of the paralleling bus, or the system is divided into districts which are normally tied together with relatively low-capacity ties between each district to maintain the system in synchronism as an aid to operation under

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Printed complete herein.

2. *Calculations of System Performance* by S. B. Griscom. *System Tests and Operating Connections*, by H. R. Searing and G. R. Milne.

normal conditions. With the first mentioned arrangement (Fig. 2), that is, with tie feeders between generating stations, the capacity in several stations is used to supply a wide area. Therefore, it is essential that synchronism be maintained not only between all units in one station but also between all stations. This

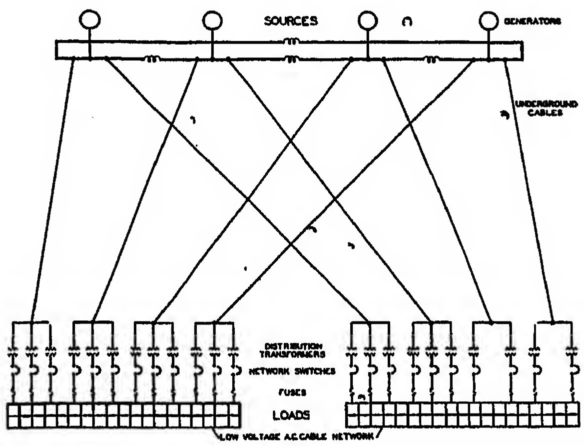

FIG. 2—SCHEMATIC CONNECTIONS CLOSE LINKED SYSTEM

has been designated as the close linked system. With the district arrangement (Fig. 3), or loose linked system, the load is definitely allocated to one adjacent station, wherein it is not essential that it should be maintained in synchronism with the remaining parts of the system. Assuming that the low-capacity ties will open properly on a major fault, this station will operate as an independent unit, alone supplying its particular district.

CHARACTERISTICS OF "CLOSE LINKED" AND "LOOSE LINKED" SYSTEMS

The close linked system requires high rupturing capacity circuit breakers, with increasing rupturing duty as the capacity of the system is increased. The fault protection is complicated, and positive back-up protection is difficult to obtain in case the primary protection fails. During system faults, service voltages are subject to excessive drops due to concentrations of current at the fault. Finally, the entire system service is at stake in case of a series of major faults.

On the other hand, the loose linked system by subdivision of the load, eliminates the likelihood of an entire system shutdown, but it does increase the probability of interruptions to each district. In addition, each station must have some efficient units if economical results are to be obtained. This system, except at district border fringes, cannot obtain the economies and reliability from diversity of a multiplicity of sources of supply. In other words, the loose linked scheme postulates that a power system can become so large that it is either economical, or imperative, to divide it into a number of separate districts power systems in order to obtain reliability.

IMPROVEMENT IN RELIABILITY OF GENERATING SOURCES

Investigation of the reliability of both the above systems made it appear that a generating station bus system providing parallel synchronizing paths would result in increased reliability to either a close linked or a loose linked system, with either ring or star bus plan. However, such an arrangement increased the switch rupturing duty and the voltage disturbances on system faults. Furthermore, it did not simplify the protection problem.

In 1924, following two years' experience with the Manhattan multiple feed a-c. network system, the author proposed for maximum reliability to operate each generator in parallel with remaining generators only on the low-voltage network.[3] This system uses the load points as a short-circuit-proof paralleling bus for all the units which are "synchronized at the load." In applying the principles established by experience with multiple-feed low-voltage network distribution to a group of generators multipled only on a low-voltage network, it was assumed that if the system were stable, the following desirable conditions would result: (a) highly reliable sources of supply, since they were not affected simultaneously by faults; (b) positive back-up fault protection; (c) minimum fault current concentrations; and (d) minimum service voltage disturbances. The definite evaluation of the synchronizing power available and of the amount necessary to keep sufficient generating sources in step to supply the load under all conditions of system faults presented problems which prohibited the immediate application of such an arrangement. The detailed determinations of these values, both by calculation and test, are described in accompanying papers.

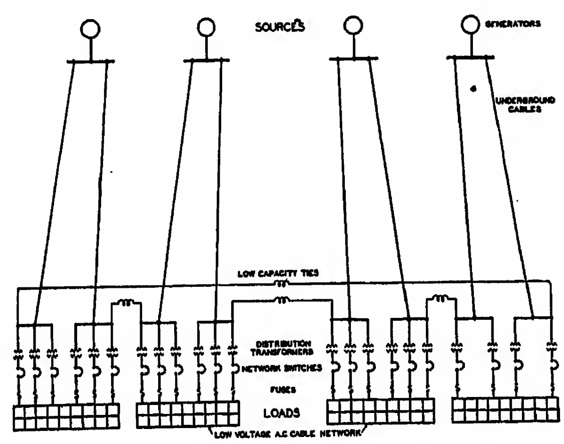

FIG. 3—SCHEMATIC CONNECTIONS LOOSE LINKED SYSTEM

The synchronizing power for the New York close linked system with this arrangement was found to be adequate. While it is less under normal conditions than that which is obtained between individual units

3. *Underground A-C. Networks*, by A. H. Kehoe, A. I. E. E. TRANS., Vol. 43, 1924, p. 848.

synchronized at the sources, yet the effective synchronizing ability at the time of a disturbance is approximately the same as with a close linked system, due to the reduced magnitude of possible faults, and the new system has high reliability due to a multiplicity of independent sources. With a loose linked system the reliability of any district would not be dependent upon the synchronizing ability of the system, but upon that of a single station. For this reason the number of possible independent sources for any district will be less than with a close linked arrangement which is considered preferable to the loose linked system if it is to be "synchronized at the load."

Reliability of Supply Synchronized at the Load

The assurance of reliability of system supply for any one fault is secured by the following considerations: Sufficient generating sources are "synchronized at the load" on a system having ample synchronizing power between the units to produce stable operation between all sources for any single fault regardless of its location, provided the fault is eliminated promptly by protective equipment. So long as enough such independent sources are in service to maintain the load, the loss of the reserve part of the capacity will not result in an interruption, since the remaining capacity is not jeopardized by this loss. The ability of a low-voltage network to eliminate its own faults[4] will provide positive back-up protection even though a reasonable percentage of subsequent failures of protective equipment do not eliminate the original fault. If a system has radial service supplied from a substation, the low-voltage bus, such as a 4-kv. substation bus, will be the last common load point and must be used for synchronizing at the load. In this case, protective devices are relied upon for secondary protection, as there is usually a number of protective devices in series backing up each other for a major fault. In the extreme condition, a fault which is not eliminated because the protective equipment failed will cause an interruption only to the substation where such failure occurs.

System Results Synchronized at the Load

With a system synchronized at the load, the current and load division between feeders may be affected somewhat except for peak conditions, when results should be the same. The magnitude of this effect, however, does not make it of major consideration. Similarly, in order to give the system the reliability obtained by diversity of supplies from a number of independent sources, the load from any generator (or bus section) should scatter to as many different load centers as possible. If this is carried to extremes, the mean length of feeder will be increased unnecessarily. It is pointed out that all units do not have to feed each and every load point, and in the New York case we did not experience any increase in feeder lengths. It should also be noted that additional capacity can be supplied at lower installation costs because of smaller capacity required for electrical connections.

The arrangement makes the maximum short-circuit currents much less than are experienced on a system having a number of generators concentrated on a single bus. Furthermore, additions to system capacity do not increase the switch rupturing duty beyond the amount required by the first installation as long as the same generating capacity is maintained on existing sections.

Since the magnitude of fault currents is materially reduced and since currents from all other units must feed through the load into the fault, the resultant voltage disturbances due to system faults are materially reduced. System service voltages during major faults approximating 60 per cent to 90 per cent of normal are to be expected instead of 20 per cent to 50 per cent of normal.

Conclusions

With ample synchronizing ability inherent in the system to give stability to a number of independent power sources, whether located in one or several different generating stations, generators synchronized at the load can be connected by supply feeders to a number of load points, thus making it impossible for one fault to affect all of the generating capacity; hence, if sufficient reserve capacity is in operation, the loss caused by a single fault cannot affect the reliability. By this method, reliability of supply depends upon having immediately available sufficient spare capacity in operation to compensate for a maximum number of possible major faults which are reasonably likely to occur in the interval required to get spare capacity in operation.

Acknowledgments

Acknowledgment is made to those engineers who between 1924 and 1928 have encouraged the development of the arrangement by stating that in their judgment the synchronizing ability would be ample with the 60-cycle New York City system. In particular, credit for bringing this sytem into operation is due to the Westinghouse engineering staff for its mathematical investigations and conclusions which were proved by test to be highly accurate.

4. *Underground A.-C. Network*, by A. H. Kehoe. A. I. E. E. Trans., 1924. Vol. 43, p. 845. Also, *Extinction of an A-C. Arc*, by J. Slepian, A. I. E. E. Trans., 1928, Vol. 47, p. 1404, and *Theory of the Deion Circuit Breaker*, by J. Slepian, A. I. E. E. Trans., 1929, Vol. 48, p. 523.

Abridgment of

"Synchronized at the Load"—II
Calculations of System Performance

BY S. B. GRISCOM[1]
Associate, A. I. E. E.

Synopsis.—This paper describes the results of calculations made for operating the Hell Gate and Sherman Creek generating stations of the United Electric Light and Power Company, synchronized at the load.

After reducing the numerous branches of the system to a simpler equivalent, calculations were made on the operation of an isolated section. These calculations indicated ample static stability and transient stability under fault conditions representing the maximum which might normally be expected.

Other calculations were made indicating that the entire system with synchronizing paths completed through the substation low-voltage busses, would likewise meet the required stability conditions.

Tentative system design factors based on the calculations and experience to date are suggested as a guide to system planning.

This paper shows a practical application of the theories and principles developed in the studies of transmission stability. In the present case, a somewhat different object was in view inasmuch as it was desired to substantiate ideas as to the feasibility of the plan of synchronizing at the load rather than to obtain numerical limits.

* * * * *

Introduction

In general, the principal reason for synchronizing generators at the load is that it gives promise of increasing the reliability of power supply from the generating sources. Having as a background the many papers and technical articles on stability written recently, there is a tendency to associate stability and reliability of service. The subjects are related to the extent that a system which is capable of reliable and continuous service necessarily possesses stability to a high degree. However, with the usually understood meaning of stability, it is entirely possible to have a stable system which may not be capable of service reliability of a high order.

An example will be used to bring out the conceptions of the term "stability" and "reliability" as used in this paper. Assume that a power system is composed of only one generating station and that all of the generators in the station are connected to one bus. Load is distributed from this bus by means of feeders connected to it through reactors of conventional value, as three or five per cent. This system would be considered stable, with generator and excitation characteristics as are in common use. However, the system might not be considered reliable because it has a vulnerable spot—the single generator bus. Major trouble on the bus or on any part of the equipment connected to it could result in a complete system outage. Thus, the system is stable but not reliable. If the bus is divided into a number of parts and the sections thus formed are connected by reactors, the combination would be regarded as having a higher order of reliability than the system with a single straight bus. Similarly, if there are two stations with connecting ties, the over-all reliability is considered as still greater. It will thus be noticed that the insertion of reactance between units of a system has improved the reliability.

Stability Requirements for Satisfactory Operation when Synchronized at the Load

The fundamental plan of synchronizing at the load is described in a companion paper by A. H. Kehoe. This plan gives a redistribution of reactance on the system so that the reactance between machines and in series with faults is considerably increased. Fig. 1

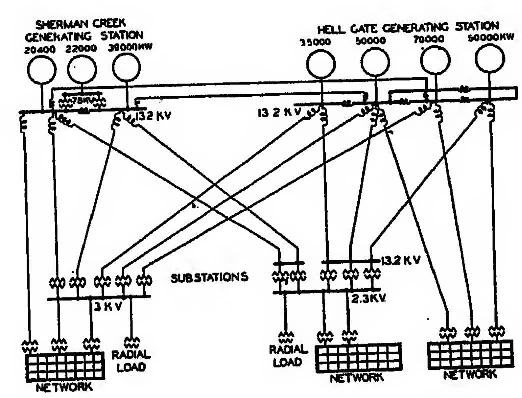

Fig. 1—Synchronized at Generating Station Busses

illustrates in a schematic manner the connections which have been in use in the 60-cycle parts of the generating stations of the United Electric Light and Power Company and in the system external to them. The generating busses were tied to one another very closely, inside the stations, by bus-tie reactors and outside of the stations by cables at generator voltage. The stations themselves were tied directly together by high-voltage cables. Fig. 2 shows the same equipment but synchronized at the load with the reactance between generating units considerably increased by the omission of the bus-tie reactors and inter-station ties, and by splitting the substation high-tension busses. From the stability point of view this scheme of con-

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Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

nection is only partly equivalent to a ring bus scheme in which high-reactance reactors are used between busses, since the actual ties between units consist of a large number of branches in parallel and because each generator tends to have symmetrical ties with each other generator. In fact, from this point of view, the arrangement is more nearly like the synchronizing bus or star bus, but does not have any points where large amounts of energy are concentrated. The stability and reliability of the synchronized at the load arrangement compared to the previous arrangement depends upon the relative amount of change in reactance in series with faults and between generating units. The calculated performance when synchronized at the load is described in this paper, while the test and operating results are described in the companion paper by Messrs. Searing and Milne.

The rigid requirements for power supply in a metropolitan area necessitate a system which has static stability under all conditions of operation and transient stability under all conditions of operation, with the

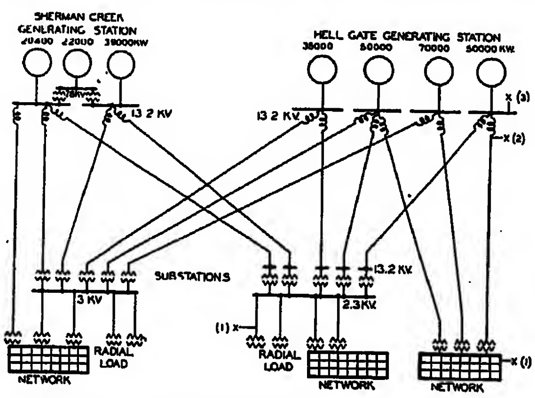

FIG. 2—SYNCHRONIZED AT THE LOAD

exception that in some cases a disturbance may result in loss of a generating unit; and this is permissible, but it is required that the remaining units maintain synchronism with one another. In addition to possessing the necessary stability, there must be no undesirable hunting between generating units. The layout of the system is such that if stability can be obtained, the requisite reliability of service will automatically be obtained, vulnerable points having been largely eliminated.

By static stability is meant that the generating units shall be capable of carrying the required load under normal conditions without loss of synchronism. With such a closely connected system it appeared likely that such would be the case, and the analysis of this point was made largely as a formality.

There are three transient conditions to be considered: One condition is a fault located more or less equidistantly from each of the generating units, as (1) on Fig. 2. From the nature of the layout it is apparent that such a fault affects all of the generators similarly and practically in proportion to the size of the machine, hence, would be almost unnoticed. Another condition is a fault on a feeder close to one generator unit, such as (2) Fig. 2. Practically, this condition resolves itself into a fault on the feeder side of a feeder reactor on one of the generating units. A fault at this location has a tendency to cause the generator nearest it to go out of step. The third transient condition is that of a short circuit on one of the generating bus sections as illustrated by (3), Fig. 2. This condition will almost invariably cause the loss of the generators connected to that bus section. However, it is required that only the remaining generators stay in synchronism with each other.

From the foregoing, it will be seen that the most important considerations from the stability point of view are that all of the generators keep in synchronism for short circuits on the feeder side of a feeder reactor, and that all of the generators except those directly involved stay in synchronism during a bus short circuit. The three-phase short circuit is the most severe and has therefore been made the basis of study.

Methods of Analysis.

There are, in general, three ways of making an analysis for stability; calculation, laboratory tests, and field tests. It was found that the major portion of the work involved was in obtaining values of the various impedances because of the unusually large number of feeders, and since a determination of these values for the existing and proposed system of the United Electric Light and Power Company was a necessary part of the program, all of the analysis was made by calculation. Later, tests were made to give an over-all check on the derivation of system impedances, machine characteristics, and the electromechanical oscillations set up by short circuits.

The general methods of calculation have been described in several papers before the Institute and details will not be given here. In all calculations, the load was considered as a shunt admittance. This assumption was necessary because of the amount of work which otherwise would have been required, but is is probably fairly accurate for the system under consideration because of the relatively large amount of lighting load. For the static stability analysis the synchronous reactances of the generators at the initial operating points were used. For the transient analyses the transient reactances of the generators were used. The effect of variations in the cross flux was not considered. Decrements of main field flux, and the general method of calculation were about as given in another paper before the Institute.

The studies which were made were divided into two groups, one being on a portion of the system which, in addition to lending itself readily to tests, also is of the type representing what appears to be the tendency in the growth of the system. This part of the system

2. *Studies of Transmission Stability.* Evans and Wagner, A. I. E. E., TRANS., Vol. 45, 1926, pp. 51-94.

was that which was fed mainly by the 120-208-volt a-c. network system. Other analyses were made covering the entire system as it was expected to be when the plan was first placed in operation. The discussion will therefore be divided between the analyses of one generating unit split from the system and operating on the networks, and the entire system with generating units separated at the generating station and synchronizing ties through the low-voltage substation busses.

Partial System Analysis

Reduction of Network. The part of the system analyzed is shown by Fig. 2 in the companion paper *System Tests and Operating Connections, Synchronized at the Load.* In this figure, each small square represents a networked area and consists of hundreds of branches. After having obtained the reactance of the network elements, values were substituted for the small squares of Fig. 2 of *System Tests and Operating Connections,* (Part III of this symposium), in accordance with the transformer capacity connected to the various cables. The effective reactance between the generator to be tested and the remainder of the system, through the networks was found in this manner. Resistance components were then added to the reactances according to what was considered to be the probable ratio of resistance to reactance. Admittances were placed along the connecting impedance between the two generating sources in proportion to the probable electrical distances of these loads from the sources. This gave a static network to which it is only necessary to add the generator reactances to proceed with the analysis.

Static Stability. The synchronous reactance of the generator under test and the remainder of the generators grouped were added at the proper ends of the connecting network, and, with the internal voltages determined in accordance with the initial loadings, completed the data necessary for obtaining a static power-angle diagram. Points were picked off of this characteristic and the generator terminal voltage computed to give the points of the voltage-power characteristic of Fig. 3, this form being more readily interpreted. It will be noted that with an initial load of 22,000-kw. at 100 per cent voltage the static stability analysis indicates that with fixed field excitation, a load of 31,500 kw. could be carried before pull-out takes place at 88 per cent voltage. This, of course, does not mean that a load higher than 31,400 kw. could not be carried, but merely represents the approximate margin for a given initial load and corresponding field excitation. This analysis indicates that there is ample static stability without the use of automatic voltage regulators.

There was some speculation as to the possibility of hunting, but this factor cannot readily be examined in advance. It was felt, however, that no hunting would occur, and when tested this was found to be the case.

Transient Stability. Analyses of transient stability were made for three-phase short circuits on a feeder, both at some distance from the station, and just outside the station where the feeder reactor was the only impedance in series with the fault and the bus. These analyses were made by the point-by-point method, calculating the changes in field flux and angular positions, and indicated that stable operation could be obtained under these conditions.

Tests were made with faults of various severity and duration, checking the general methods and conclusions, that with the reactances and short circuit currents obtaining when synchronized through the network, the system would be stable. These tests showed that the equivalent reactance between the tested generator and the remainder of the system was about 46 per cent based on the machine rating. The maximum short circuit was 2½ times rated generator current (instantaneous symmetrical) and the maximum duration of short circuit was 1.8 seconds. The initial load was approximately 60 per cent of rated load, at rated power factor and no automatic voltage regulators were in use. The generator had a short circuit ratio of 0.76. These figures show quite clearly that *high short-circuit ratios are not required of turbo generators for power supply in relatively closely connected system.*

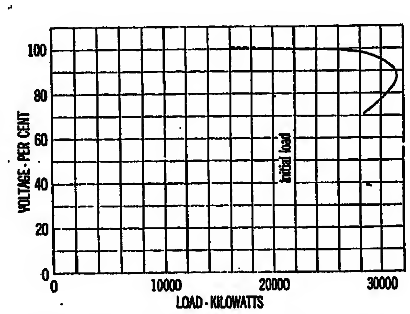

Fig. 3—Voltage-Power Characteristic, Indicating Static Stability

Entire System

In analyzing the entire generating system of the United Electric Light and Power Company, there are two transient stability requirements to be met as well as the static stability requirement. It must be capable of withstanding a three-phase short circuit on one of the generating busses without the other generators losing synchronism, and it must be able to withstand feeder short circuits. It was not considered necessary to repeat the analysis of static stability in view of the results obtained on the portion of the system previously analyzed.

The proposed initial layout for synchronizing at the load is shown in the companion paper by Messrs. Searing and Milne and it will be noted that the synchronizing tie in this case is principally through the substations rather than through the a-c. low-voltage network.

A calculating board set-up was made as in the previous

studies to obtain the equivalent mesh of the ties external to the generating stations. The reactances of the various generators were then added to the mesh, and another calculating board study made for the equivalent mesh including the internal reactances of the generators. The following table shows the per cent reactance between the internal voltage of the generators connected to each bus and the internal voltages of all other generators combined, based on the combined ratings of the generators connected to the bus in question.

Bus section	Per cent reactance
N. E.	30 per cent
S. W.	29 per cent
4	50 per cent
5 and 6	50 per cent
7	50 per cent
8 and 9	52 per cent

These values indicate that the system is at present somewhat unbalanced with reference to the synchronizing power of the various generators. This is due to a temporary local condition in that the feeder capacities at Hell Gate and Sherman Creek are not in proportion to the generator capacities. This condition will gradually disappear as cable rearrangements and additions are made.

Bus Short Circuit. A solid three-phase short circuit

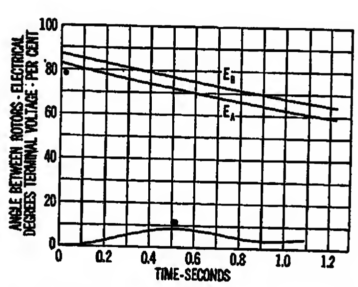

FIG. 4—EFFECT OF BUS SHORT CIRCUIT WITH ENTIRE SYSTEM SYNCHRONIZED AT THE LOAD

was considered as applied to the bus section which gave the largest short-circuit current. Under this condition, the generators operating on this bus section immediately lose all of their load, and over-speed. The resultant effect on the other generating bus sections depends upon how much dissymmetry there is in the layout. With an entirely symmetrical layout, the other generators would tend to speed up in unison with no tendency to lose synchronism with each other. In order to simplify the analysis, the results were calculated on the basis of reducing the system to two equivalent generating groups. One of these groups included those generators on the bus section having the maximum differences from the others, while the remaining generators were grouped together.

Fig. 4 shows the results obtained. It will be noted that the angular oscillation between the generating groups is very small, and that the drop in voltage is quite nominal considering the character of the fault condition. This analysis indicates that the proposed scheme can operate and furnish stable and reliable service with a solid three-phase short circuit on one bus, provided there is enough generating capacity in reserve, and provided that the bus section is isolated in a reasonable time by the opening of feeder switches.

Feeder Short Circuits. A transient stability analysis was next made with a short circuit on the feeder side of a feeder reactor, the reactance of which was such as to produce a short-circuit current of three times the full-load current of the generators connected to the bus. To facilitate calculations, the generators were grouped so that those on the bus having the short-circuited feeder constituted one group, and all other generators the other group. The results of this analysis are shown by

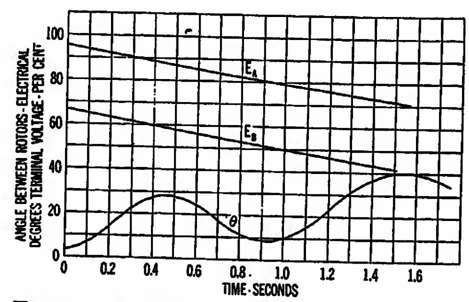

FIG. 5—EFFECT OF FEEDER SHORT CIRCUITS WITH ENTIRE SYSTEM SYNCHRONIZED AT THE LOAD

Fig. 5. It will be observed that this condition sets up a considerably larger oscillation than the bus short circuit, but that considerably less voltage disturbances are set up. This calculation indicates that short circuits up to three times the current rating of the nearest generators and having a duration up to about two sec. can be handled successfully. However, where possible, both the current magnitudes and duration should be reduced, as this will constitute less hazards and give less voltage disturbance.

TENTATIVE DESIGN CONSTANTS

From the studies and tests made thus far, the following values are suggested as reasonable for system design.

Synchronizing Ability between Generators. The impedance between the internal voltage of one generating unit and the internal voltage of all other units of the same system in parallel (not including ties to other systems) should lie between 40 and 60 per cent, based on the kv-a. rating of the generating unit.

Synchronizing Ability between Systems. The impedance between two systems both of which are synchronized at the load should not exceed 200 per cent on the rating of the smaller of the two systems.

Short Circuits. The maximum instantaneous symmetrical short-circuit current on a feeder from a

generating unit should not exceed 2½ times the normal current capacity of the generating unit and should not be permitted to last longer than 1½ sec. For simplicity this value should be obtained on the basis of a short circuit with the highest capacity feeder reactor in series with the generating unit on a three-phase short circuit. For higher values of short-circuit current the duration of short circuit must be reduced.

Circuit Breaker Capacity. With the above system proportions, the interrupting duty on a generating unit breaker will not, in general, exceed 1¾ times the generator short-circuit current.

Abridgment of

"Synchronized at the Load"—III

System Tests and Operating Connections

BY H. R. SEARING[1] and G. R. MILNE[2]

Member, A. I. E. E. Associate, A. I. E. E.

Synopsis.—*System test results, operating connections, and experience with the New York City system synchronized at the load are given. Data obtained by test are presented, showing the behavior of the system when generators are operated synchronized only through a low-voltage a-c. secondary network.*

The adaptation of this method of connections to the New York City 60-cycle system, including system layout, station and feeder rearrangement, and automatic recording apparatus, is described.

Experience with these connections has demonstrated that stable performance of prime movers is obtained, load and wattless control is simplified, oil circuit breaker duty is reduced, and voltage fluctuation at customer's service during system disturbances is materially decreased.

* * * * *

THE New York City 60-cycle system is principally supplied by the generating stations of the United Electric Light & Power Company with interconnections to the Brooklyn Edison Company system. Primary energy is supplied to the United distribution system on Manhattan Island and to the Bronx, Westchester, and Queens districts.

Two stations—Hell Gate with a 60-cycle capacity of 500,000 kw. and Sherman Creek with a 60-cycle capacity of 105,000 kw., supply the systems. In addition to the interconnections with the Hudson Avenue Station of the Brooklyn Edison Company, there are connections to the 25-cycle system through five frequency changers, aggregating 185,000 kw.

The 60-cycle distribution load on Manhattan is supplied almost entirely by multiple feed low-voltage networks, having a total connected transformer capacity of 100,000 kv-a. Similar networks are in operation in the Bronx and in parts of Queens. Service to the remaining districts, as well as the major supply to these networks, is furnished through conventional distribution substations. In network districts, however, the building of new substations has been discontinued and the distribution transformers are supplied at generator voltage.

The high degree of service reliability required by high-load density districts called for a system superior to the usual radial arrangement. This led to development of the multiple-feed a-c. low-voltage network which was first placed in service in Manhattan in 1922. Experience with this system of distribution with rapidly expanding application indicates that the reliability of service is now limited by that of the generating sources.

Operating experience has shown that a bus fault on the conventional ring bus arrangement of generator connections with high-capacity interstation ties will cause outage to parts of the system, and serious disturbance to the remainder.

The companion papers describe a new arrangement of system connections to the generating sources—synchronized at the load—which applies the principle of multiple feeds upon which the network distribution system is based.

With this arrangement, a generator about to be placed in service is first synchronized with an adjacent unit and connected to the bus in the usual manner. After the generator is supplying the load of the bus section to which it is connected, the high-tension connections to the adjacent unit are opened, leaving the generator connected only through the low-voltage networks.

Experimental Determination of Network Impedance

The proposed arrangement, contemplated a system in which the only connections between generators would be those through the secondary network. While the system constants from the generator to the network were susceptible to accurate calculation, there was no information available as to the impedance of the

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secondary mains system; hence, it was desirable to obtain test confirmation of the calculated values.

The results of this test, which was made on the Times Square network, showed the impedance of the network from the transformer terminal points of any feeder to an imaginary star point to be 5.1 per cent, based on the transformer kv-a. connected to the feeder.

The value of 5.1 per cent agrees reasonably well with a calculated value of 4.6 per cent for a similar case when it is considered that the calculations were made on a different network (Inwood) and the network under test was distorted by having two of its normal feeders out of service.

System Tests

Calculations made on an arrangement in which one of the generators was connected to the remainder of the system only through low-voltage networks, forecasted successful operation during normal loading and feeder short circuits on the system connected to this generator. Therefore arrangements were made to test the performance of one generator at Sherman Creek Station synchronized with the remainder of the system through the Manhattan secondary network.

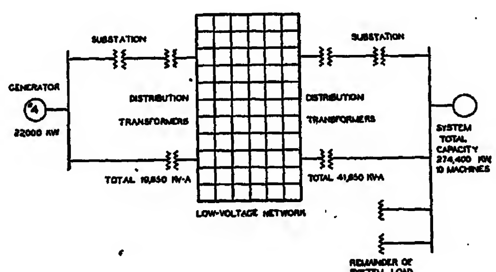

Fig. 1—Schematic Connections for System Test

Due to the limited capacity of network feeders available for this purpose, the coupling between the generator thus isolated and the remainder of the system was small when compared to the generator capacity, and therefore the test conditions were more severe than would be expected under an arrangement where the generator capacity and network interlinkings were comparable. The specific purposes of the test were to determine the stability of a generator operating under such conditions and subjected to feeder short circuits, to check the action of automatic network switches having sensitive reverse power settings, and to determine the effect of such operation on the customer's service.

The system connections at the time of test are indicated in Fig. 1. Generator No. 4 was connected to the low-voltage networks through a number of feeders having a total connected distribution transformer capacity of 19,850 kv-a. The remainder of the system was connected to these same networks through distribution transformers, totaling 41,650 kv-a.

During the test, the approximate loading was 12,000 kw. on generator No. 4 at Sherman Creek and 218,310 kw. on the generators connected to the main system, of which it is estimated 25,200 kw. was supplied to the low-voltage networks included in the test.

Neglecting the effect of network load, the impedance between generator No. 4 and the remainder of the system including internal reactances of all machines was approximately 60 per cent, based on the rating of generator No. 4, 25,900 kv-a. During the tests, all feeder regulators[6] were on automatic operation. All generators on the system are arranged for manual excitation control.

On May 7, 1928 the two systems were set up and operated, synchronized through the low-voltage networks from 8:52 p.m. to 9:57 p.m. Although no short circuits were applied, the machine showed no signs of hunting and at all times gave stable operation. During the evenings of May 8, 9, and 11, the two systems were set up and a total of nine three-phase short circuits was placed on the auxiliary system, each short circuit being cleared automatically in a predetermined time. These short circuits were made at various locations over a 7.8-kv. feeder, the last three being applied directly outside the feeder reactors at the generating station.

Oscillographic equipment was used at Sherman Creek to measure:

a. Current and power of short-circuited feeder
b. Terminal voltage of generator No. 4
c. Voltage of main system at Sherman Creek
d. Differential between above voltages
e. Differential watts using current of generator No. 4 and differential volts
f. Current, power, throttle position, and field current of generator No. 4.

In addition, stroboscopic equipment was used during the tests to view the rotor displacement of generator No. 4 during the disturbances.

Nine recording voltmeters were installed at various locations on the networks to obtain a record of the voltage dip caused by the short circuits.

The total number of network switches involved in these tests was 649, of which 208 were connected to the auxiliary system and 441 to the main system.

A summary of the results of all the short-circuit tests is given in Table III. Detailed results of the short circuit applied just outside the station reactors for 1.24 sec. are given in Fig. 4.

Stability

The test results showed that the generator was very stable when synchronized through the low-voltage networks, although the capacity of the connected distribution transformers was less than would be expected under normal system planning. No hunting occurred and even with the most severe short circuit applied just outside the feeder reactors at the generating station for 1.8 sec., the stroboscope indicated a maximum shift of 40 electrical degrees lead between this machine and the remainder of the system.

TABLE III

SUMMARY SHORT-CIRCUIT TESTS SYNCHRONIZED AT THE LOAD MAY 7-11, 1928

Date	Time	Duration seconds	Load on gen. No. 4 kw.	*Current in short circuited feeder amps.	Power in short circuited feeder kw.	Voltage drop at gen. No. 4 per cent	Voltage drop on networks per cent		†Max. swing of gen. No. 4 during short-circuit electrical degrees
							Max.	Min.	
5- 8-28	9:00 p.m.	0.29	13,500	2010	3800	16	13	8	4 lead
5- 9-28	8:15 p.m.	0.28	11,500	3120	9400	21.5	16	10	8 lead
5- 9-28	8:35 p m.	0.55	12,500	3090	9400	28.5	21	11.5	8 lead
5- 9-28	8:57 p.m.	0.92	11,700	3120	9400	28.5	21	13.0	9 lead
5- 9-28	9:15 p.m.	1.35	12,750	3120	9400	31.0	21	11.5	15 lead
5- 9-28	9:41 p.m.	1.82	12,750	3120	9400	31.0	21	12	19 lead
5-11-28	8:20 p.m.	0.67	12,500	4720	..	44.5	33	19.5	26 lead
5-11-28	9:02 p.m.	1.24	12,250	4720	800	45.0	34	19	34 lead
5-11-28	9:20 p.m.	1.80	12,900	4720	..	44.5	33	20	40 lead

*Instantaneous symmetrical r. m. s. value.

†As viewed with stroboscope.

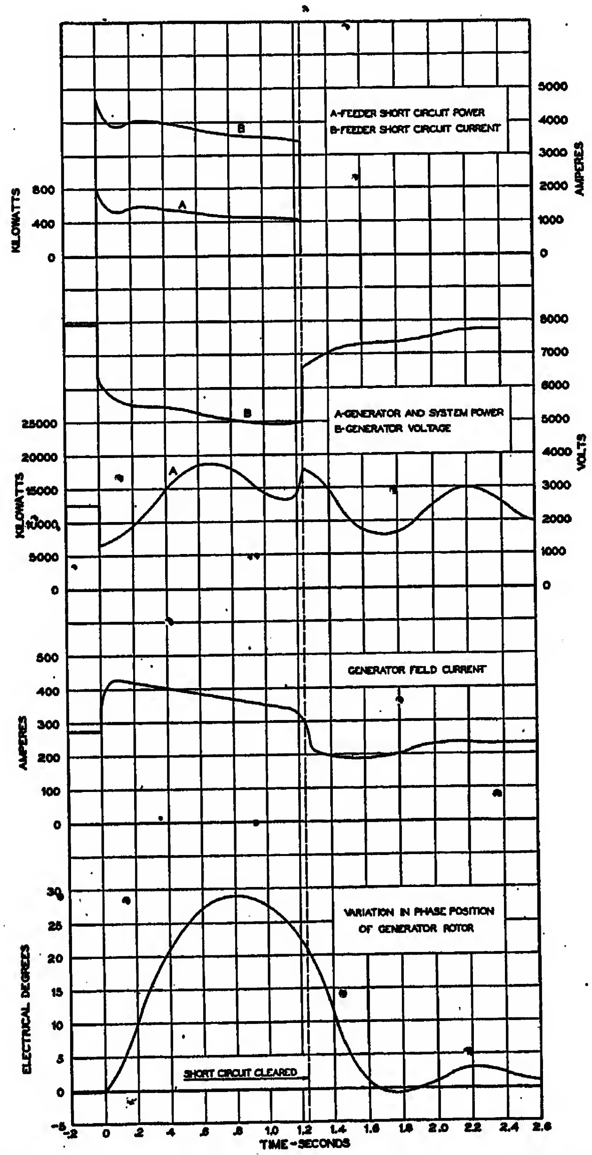

FIG. 4—PERFORMANCE CURVES OF GENERATOR NO. 4 AND SHORT-CIRCUITED FEEDER. TEST OF MAY 11, 1928, 9:02 P. M.

Network Switch Operation

The tests demonstrated that when the system was operated so that the maximum kw. load imposed by a feeder short circuit did not exceed the normal kw. load on the generator, network switches of the sensitive reverse power type remained closed even under the most severe condition of feeder short circuit. The voltage on the network was sustained at a value which precluded any network switches of the low-voltage release type from operating prematurely due to low voltage. During the test, a maximum of 1.4 per cent of the network switches connected to the machine under short circuit opened and reclosed.

System Disturbances

On the networks which were partially supplied by the machine under test, the voltage drop on short circuit varied from 10 per cent to 34 per cent. It should be noted that this drop was much larger than should occur in normal operation because in the test the network capacity was distributed in such a manner as to give the equivalent of a two-circuit network.

System Layout for Initial Operation

These tests demonstrated the stability of the arrangement for any disturbance beyond the feeder reactors and substantiated the general method of analytical treatment.

It was decided to proceed with the layout for operating the entire system synchronized at the load. As there were not sufficient networks to adopt the scheme in its entirety, the 4-kv. substation busses were considered as load points and feeder connections arranged so that the coupling between generating bus sections was provided through transformation and highly reactive ties. This was a departure from the original concept, but not from the basic principle, and represents an expedient to be utilized only until sufficient network capacity is available to complete the entire plan.

Calculations made on the proposed connections indicated that under the conditions of a bus short circuit on one section, all generators, except the one short-circuited would remain in synchronism.

It was not desirable, however, to subject the system to a bus short circuit under this arrangement in order to check the calculations and therefore it was decided to proceed with operation under this plan and provide automatic recording apparatus which would give test data under the normal system disturbances from which

the system behavior under a bus short-circuit condition could be predicted.

Nine-element oscillographs were installed at Sherman Creek and Hell Gate arranged for automatic operation. The principal measurements are those of phase angles between a common average system load voltage and the internal voltage of each generating group which is available at all times by means of pilot generators coupled to the shafts of the mains units. Various other data are recorded to assist in predictions of system behavior.

In planning the system layout for operating synchronized at the load, it became apparent that the ratio of feeder capacity to generator capacity should be approximately the same for all sections; and that any substation or network district should be supplied from different generating station sections so as to maintain diversified feeds under all operating conditions. The first feature is desirable, not only for load division but in order that each generating section may carry its share of the system wattless kv-a. The second feature is obviously necessary for service reliability. Furthermore, the feeder grouping and capacity mu stbe such that generating units and also stations may be loaded to their economical point.

The general plan of operating the entire system synchronized at the load contemplated keeping the tie feeders between Hell Gate and Sherman Creek open at all times. Each of the 13.2-kv. bus sections, four at Hell Gate and two at Sherman Creek, would operate as separate sources during the peak period.

During the light-load period, Hell Gate would operate in two sections and Sherman Creek as a single-bus station. It should be realized, however, that these operating arrangements are flexible and Hell Gate has been operated with various grouping of sections.

As Sherman Creek had too much feeder capacity in proportion to generator capacity, some of the feeders serving the Manhattan and Bronx Districts were transferred to Hell Gate. At each generating station some rearrangement of feeders on the various groups was necessary in order to diversify the feeds to any given substation or network district under any of the various generator groupings. Furthermore, in some substations, no sectionalizing switches were available to permit connecting feeders directly to transformer banks and it was decided to sectionalize permanently the main bus of such stations.

While copper ties between bus sections were avoided wherever possible, it was necessary to continue the highly reactive high-tension loop customers to supply large customers.

The high-tension tie feeders between the Hudson Avenue Station of the Brooklyn Edison Company and Hell Gate were continued, and the reactance value of these ties (112 per cent based on Hudson Avenue) was found to be well within limits.

The Queens district lies between Hudson Avenue and Hell Gate and the increase in load in this district necessitated additional feeders from Hudson Avenue. Accordingly plans were made and work is under way to maintain synchronism between Hell Gate and Hudson Avenue through the 4-kv. busses of the Queens substations, and through frequency changers connecting to the common 25-cycle system of the allied companies.

In order that a unit may be stable under the condition of feeder short circuit, the ratio of short-circuit current to generator full load should not exceed a value tentatively set at 2.5; and the system was set up so that all usual feeder faults would fall within this ratio.

Reduction of Oil Circuit Breaker Duty

One of the advantages of the proposed arrangement was evidenced in the reduction of oil circuit breaker duty. Hell Gate Station was originally planned for five 50,000-kw., 60-cycle units and the main oil circuit breakers which were rated at 1,500,000 kv-a. were of ample capacity to clear a bus short circuit.

This initial layout was greatly exceeded, and one of the problems introduced by the installation of two 160,000-kw. turbines to complete the station was the fact that the breakers would be unable to clear a bus short circuit which gave a calculated instantaneous symmetrical value of 2,900,000 kv-a.

With the synchronized-at-the-load arrangement, the duty on oil circuit breakers was reduced and one of the immediate advantages aside from increased reliability was the fact that maximum duty on these oil breakers would still be within their rated capacity.

Operating Experience

The proposed system layout contemplated generator No. 8 (160,000 kw.) being in service at Hell Gate. Since this generator was not available, it was decided to proceed with the program with modifications, using existing capacity.

The modified arrangement was placed in operation February 13, 1929, when Hell Gate and Sherman Creek Stations were operated "synchronized-at-the-load" with Hell Gate connected to the Hudson Avenue Station of the Brooklyn Edison Company, through the high-tension tie feeders. Tests were made to determine the extent to which the system wattless kv-a. could be controlled in each of the two generating stations, and in general, it was noted that wattless control was more flexible than under the prior arrangement.

Previous to the new operating arrangement, because of its high feeder capacity, Sherman Creek was necessarily operated to prevent wattless kv-a. overloading at a lower voltage than Hell Gate. With the set-up of the new system, however, the wattless kv-a. is more easily controlled than formerly. Up to the point where a feeder becomes overloaded, load may be shifted from one section to another by the turbine throttle,

after which further load shift must be effected by switching banks from one feeder to another at the substation.

While the main synchronizing path is at present through the 4-kv. substation busses, a number of generating station feeders connected directly to the network. No difficulty has been experienced with the network switches which are of the sensitive reverse power type.

The voltage of the system is considerably less affected by feeder short circuits under the new arrangement. The disturbances caused by faults on a high-capacity feeder showed an average voltage drop of 9 per cent synchronized at the load compared with 20.7 per cent with the previous connections.

All generating units have operated in a steady manner both with normal loading and under a number of system disturbances. Records from the automatic oscillographs recently installed will give quantitative information as to system performance.

Test results have verified the calculations, and operating experience thus far has substantiated the predicted advantages of a system synchronized at the load.

The Engineer, Practical Idealist

President's Address*

BY R. F. SCHUCHARDT

THE Institute, meeting here in convention on the "stern and rock bound coast" of New England, finds itself on historic ground. In this region are located many battle fields, of arms and of intellect, that have left their deep impress on our civilization. The battle fields of arms are marked by monuments that are now shrines of an appreciative people. The battles of the intellect, though often accompanied by bloodshed, are not so well remembered. Bunker Hill is fresher in our minds than are Salem and Roger Williams, yet Williams' heroic struggle for freedom of thought paved the way for that later struggle marked by the shaft on Bunker Hill.

The freedom we enjoy today, freedom of thought and of political action, we owe to those who fought and suffered and bled in generations past. We are worthy possessors of our heritages only if we in turn give thought to the morrow, and in our work today plan so that the morrow will offer a richer life for our children.

Are we of the engineering kinship, who are presumably well trained to determine facts and to reason from them, giving sufficient thought to the morrow? It is well on this occasion, in the atmosphere of these significant historical surroundings, to pause a few moments before taking up the technical part of our work, to consider briefly some problems of this interesting workaday world of ours, to try to glean from the study some of the trends in our civilization and our relation to them.

If it is true, as Professor East has written,[1] that man stands today at the parting of the ways, with the choice of controlling his own destiny or of being tossed about by the blind forces of his environment, then it will be well for the engineer to concern himself more with the environment. He should take a larger part in the leadership seeking solution for the human problems that vitally influence the trends. Surely the bewildering complexities of today require clear thinking, and who is better fitted for a thoughtful analysis of the factors on which development and progress depend?

With this as a background, I should like to suggest some thoughts that appear worthy of your careful consideration.

The history of mankind shows a successive rise and decay of great civilizations. Reflection on this leads to the frequent questions: Is our civilization headed for decay? Are we also, like former ages, unable to bear up under prosperity and power? I shall not venture an answer, but let us consider some facts. Earlier civilizations existed on relatively small areas. Today the entire world is a neighborhood —made so largely by the work of the engineer. Not only is it a neighborhood world but also a much more densely populated world, and the great increase in population, we are told, started with the industrial revolution in the eighteenth century—also based on the engineer's work. The engineer, responsible for so much that *is*, cannot shirk his responsibility for correct guidance of what *shall be*.

Our civilization has come to be known as the Machine Age and as such it is both lauded and condemned. President Glenn Frank* in a splendidly balanced analysis of the machine age and its trends, offers this comment:

". . . the masses have more to hope for from great engineers, great inventors and great captains of industry than from the social reformers who woo them with their panaceas. The greatest social progress of the next fifty years is likely to come as a by-product of technical progress."

Even in the Orient, where the materialism of the Occident is thought to sound the death knell of the spiritual, we find the famous Chinese philosopher, Dr. Hu Shih, in agreement, for he sees science and the new technology as the forces which restored to man a sense

1. "Mankind at the Cross Roads" by Edward M. East.

Delivered at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Printed complete herein.

*"Where is this Machine Age Taking Us" by Glenn Frank, in *The Magazine of Business*, Oct. 1927.

of self confidence and thus created the modern civilization of the West. He concludes that inventors, scientists and producers of goods deserve the blessings of their fellows as spiritual leaders.

Others of the interesting group that contributed to the symposium, "Whither Mankind," inspired and edited by Charles A. Beard, seem to concur. As Dr. Beard summarized in part; "They are not oblivious to the evils of the modern order, but they do not concede that any other system, could it be freely chosen in place of machine civilization, would confer more dignity upon human nature, make life on the whole richer in satisfaction, widen the opportunity for exercising our noblest faculties, or give a sublimer meaning to the universe in which we labor.'

With these encouragements let us try to see some of the things about us as they are. Let each of us compare this world of our experience with the dream world of our ideals. Let us see if as engineers we have not an exceptional opportunity to gain in our individual lives that true satisfaction which comes from an attempt to leave the world a better place than we found it. But first let us recognize that an engineer today is far more than Treadgold defined him nearly a century ago. In addition to "directing the powers of nature for the service of man" he now adds to the common welfare also in fields more human. He finds himself occupied at times in social guidance so that the tools he has provided shall be properly used

One of the most significant and important trends of this day is the continuing movement of population from the rural regions to the urban, which, with the great increase in the world's population, is thus rapidly accelerating the growth of cities. The engineer's machinery makes it possible to provide the necessary food with the expenditure of a lesser manpower than formerly and his transportation developments readily bring the food to the urban population. But with rapidly increasing population the problem becomes more and more difficult.

Professor East cites figures to prove that the maximum food supply that can be produced on the land area of this globe available for that purpose will support a population of fifty-two hundred millions, a figure which at the present rate of increase, he says, will be reached in about a century. Long before that time it will become necessary to bring into production land which is now largely arid and difficult of access, and even then, occasional crop failures will result in widespread starvation.

We can leave to the medical profession and to the biologists the task of checking population increase, but let us engineers face some of the attendant problems. We are not directly concerned with the exact decade when world saturation will be reached but we are vitally concerned with the provisions for living and for advancing civilization while man's neighbors are crowding closer and closer. The marvels of science have lulled the layman into a false sense of security. They have given him faith to believe that with the scientist and the engineer on the job the future will take care of itself. Perhaps it will, but only if the thinkers and the doers of this generation and those who follow put themselves earnestly to the task. Intelligent thinking usually leads to intelligent action. No engineer worthy of the name can take a laissez-faire attitude on problems that deeply affect human welfare and progress.

How does the engineer picture the future city? Is it to be a mechanical Colossus full of ingenious provisions for commerce and industry, for housing and for getting about, or will it be a place where man still has some contact with nature? The growth of our cities is both upward and outward. The upward limit is moving higher and higher, for both business houses and multiple dwellings, and all of the ground area that was formerly devoted to low buildings is being covered by the higher structures. The engineering problems of transportation, of light and air and health for the highly congested population are not impossible of solution but we must admit that they are being taken care of only in part. Multiple decked streets above and below ground, huge ventilators, air conditioning devices, artificial light and other necesssary contrivances are relatively easy to plan, though some of them are very expensive to provide; but is the sort of civilization that is likely to develop in a city of that character the kind that makes for a richer and nobler living? Are we building the City and forgetting the Man, as Grosvenor Atterbury[2] suggests, and are we not fast losing our sense of values?

You remember the Greek legend of Hercules and his encounter with Antaeus, the giant whom Hercules met when on his trip to get the golden apples. Antaeus was a son of Mother Earth and each time he touched the ground his strength grew tenfold. Hercules wrestling with the giant noticed this increased strength so he finally caught him up and held him in the air. Then, no longer having contact with Mother Earth, the giant's strength sank and life ebbed away with it. Is this not symbolic of man's experience when contact with nature is lost? Can a life develop properly when shuttling in crowded cars, through crowded streets or supercrowded subways, between an office which sees the sun for twenty or forty minutes a day and an apartment home in a high building closely touching elbows with neighboring high buildings? Is there a social problem involved in such city building and has the engineer no concern in it?

Our physical surroundings, things we can change if we will, offer a fertile field for the interest of engineers with their vision and with their desire for lifting life to higher levels. I suggest that we give more study to this and similar city problems and that we occasionally discuss them at Institute meetings, especially in our metropolitan sections.

Let us consider some of the problems that are, as

2. "Our Monster City and Its Life" in *N. Y. Times Magazine*, Jan. 13, 1929.

it were, at our elbow. One is that of automobile engine exhaust in our cities, which has received all too little attention. This presents a serious health problem in the deep canyon-like streets. Investigators of carbon monoxide poisoning declare that this deadly poison is often found in city streets in sufficient quantities to impair health, and in some instances to be the proximate cause of death. And with the traffic jams on country highways, the holiday outing is now far from a health trip.

While on the subject of air pollution let us in passing note the factory and the apartment house chimmeys that still frequently belch forth dense clouds, often robbing man of beauty and of health. The engineer has provided a partial cure, but even our giant power stations, which receive the most expert engineering attention, still leave something to be desired.

There is another handicap to which little thought is given,—the deleterious effect of noise on the nervous system. Scientific tests have shown a marked reduction in labor efficiency due to noise, and British physicians have even advocated an act of Parliament prohibiting needless noise in the interests of the nation's health. Certain it is that our present day business and professional life draws heavily on our nerves, and all too many men collapse under the strain. Relief from noise as one contributor to the strain is thus a direct public benefit.

And how much are we interested in the backyard regions of our industrial cities? Many of these reflect little credit on our advanced civilization. Disorderly dumpheaps and scrap piles are still all too common. They enrich no lives spent among them; rather they are likely to develop that element in our citizenry with which the forces of law and order are in constant conflict. The appalling waste that this entails affects much more than our taxes. Good housing and neighborhood cleanliness go far toward making life for the lowly conform more nearly to the picture of today's accomplishments that we paint with such pride.

The engineer knows that most of our cities have grown more or less hodge podge during the crude developmental years of our country. He knows also that correct growth demands guidance, and this means a city plan. Fortunately many cities, taking the lesson from the important European centers, have seen the wisdom of proper planning and are correcting misfits of earlier decades and are providing better guidance for the future. But the problem is today one of even greater extent—one of regional planning, and engineering enters largely into this also. Here is a field which arouses the enthusiastic interest of every true engineer. He realizes that the suburban regions are rapidly filling with dwellings and to some extent with factories. He knows that if life is to be lifted to better things these newer developments must be coordinated properly so health, convenience, beauty, and the opportunity for wholesome family life may all be properly provided for. In this and similar activities the engineer will seek the greatest dividends in terms of human happiness.

The increasing population, Professor East says, requires that each year forty million acres more must be tilled and harvested than the year before to provide sufficient food, and this clearly makes countries more and more dependent on one another and at times will shift the direction of the dependence. The engineer has brought countries together by rapid transportation, by land, by sea and by air, and has tied them still closer by achievements in communication, and now even by international power lines. What can he do to hold them together as friendly neighbors? The answer here goes to the very bottom of man's relation to man.

The material work of the engineer deals with nature's laws. He knows he must understand these laws and must use truth in his work or it will fail. Engineering analysis applied to human relations similarly seeks to find the underlying laws. A study of past civilizations indicates that they failed because of violation of that basic social law which bids us do unto others as we would have them do unto us. Is it too idealistic to expect improvement in our day to come as a result of more engineering in government, that is, more of the engineering method applied to the solution of questions that tend to bring discord between peoples and between people? There is encouragement in the statement made by Bertrand Russell,[3] "I look, therefore, to the western nations, and more particularly to America, to establish first that more humane, more stable and more truly scientific civilization toward which, as I hope, the world is tending."

Technical achievement has almost eliminated manual drudgery. The habit of technology to be guided by basic law holds out promise that "man's inhumanity to man" may likewise be banished. Is this also too optimistic? Has human nature remained unchanged through the ages, as is so often stated? May I refer the pessimists, if there be such here, to any story that portrays life during earlier periods, as for instance, "Power" by Leon Feuchtwanger. The reader of this gripping tale of the ruthless standards of the eighteenth century will congratulate himself that he is living in the twentieth.

Our machine civilization is still young, and we can attribute to growing pains many of the conditions that today prevent man's best development. However, a look toward the horizon will show many encouraging signs.

Our country, appreciating the keen need of the time for the engineering approach to the important problems of state, has elected an outstanding engineer to the presidency. In other countries the engineer must similarly stand at or near the helm if this civilization is to survive. This does not mean that he alone is to be the savior of mankind, but in this age of cooperation, the engineer, together with the doctor, the lawyer, the economist, the sociologist and other trained minds, must apply himself to a scientific solution of social

3. "Whither Mankind" edited by Charles A. Beard.

problems in addition to furthering material development. He must join forces with all those

> ". . . . whose law is reason; who depend(s)
> Upon that law as on the best of friends,"

with men who can find facts and who can face them boldly and honestly.

The engineer's work has started many trends in the direction of relief from some of the world's growing difficulties. A notable one is the spread of electric power into areas away from congestion, thereby permitting at least a partial decentralization of industries and of population. This spread is greatly advanced by the interconnection of power systems now so common all over the country, while the ease of getting about with automobiles is another important factor. A further material aid is the extension of electric distribution lines into rural regions so that modern methods can be applied increasingly to agriculture, both in the field and in the home, while the telephone and radio are keeping farm operators in touch with the latest in music and education. Great as the progress has been, much still remains to be done in these fields.

Among other items that bring cheer and stimulate optimism may be mentioned the increasing interest now being taken in sane city and regional planning, the efforts of important industries looking toward elimination of waste and the conservation of our resources, the conversion of former wastes into profitable by-products and particularly the growing reclamation of wastes in agriculture.

But here is a bit of pessimism.—The high speed at which life seems to be driven today and the apparent immersion of large numbers in gross materialism has filled some people with fear and misgivings regarding the future. Thus we have the Bishop of Ripon seriously suggesting a ten year holiday in science to give the culture of the soul an opportunity to catch up with the rapid material progress. But the fear that the "spirit" cannot grow in an atmosphere of "science" is not a new one. A century ago Edgar Allen Poe in his Sonnet to Science wrote in part

> "Hast thou not dragged Diana from her car,
> And driven the hamadryad from the wood
> To seek shelter in some happier star?
> Hast thou not torn the naiad from her flood,
> . . . ."

The feeling that our present material progress is not really making for a richer life is expressed by many more. Even our own Lorado Taft, with a fine enthusiasm for beauty and an outstanding genius for creating it, is led by his observation to conclude that Americans are practically immune to the arts, have no joy in creating, and are not interested in the most important thing of all, the creation of an ideal civilization.

What answer have we engineer optimists to these critics?—

The good bishop sees but a small part of the picture and that not the bright and inspiring part. When the young Poe wrote his sonnet the Age of Electricity had not dawned. His hamadryads and naiads would today be quite at home with most of our scientists and engineers. And our gifted sculptor seems to feel that the progress made through technology expresses itself mainly in jazz. He fails apparently to see the poetry in the work of a Millikan, a Langmuir, a Steinmetz, or an Edison. He should see, as Pupin and others so clearly see, the idealism of the American machine.

The engineer with his enthusiasm over the human purpose of technology's accomplishments is guided by his ideal of a better living for man, but he keeps his feet on the ground in a practical effort to reach this goal step by step. He appreciates that

> "Heaven is not reached by a single bound;
> But we build the ladder by which we rise
> From the lowly earth to the vaulted skies,
> And we mount to its summit round by round."

The important thing is to be mounting the rounds. That we are moving onward and upward I for one firmly believe.

Is not one true indication of the direction in which we are moving found in the growing appreciation of beauty? The advertising pages of our magazines clearly show the turn of the tide. On every hand commercial competition seems to be along lines of greatest devotion to a beautiful product, and this is not confined to automobiles and bathroom fixtures. Art, which Henry James called "the shadow of humanity," is at last finding its place in industry.

The engineer accepts the line from Keat's famous Ode

> "Beauty is truth, truth beauty."

He is conscious of the beauty and the romance in many of the facts he deals with but he does not let his enthusiasm over the beauty, or his dreaming stirred by the romance, blind him to a proper weighing of the facts. Rather he develops from his dreaming a use of the facts for the further enrichment of life.

And what of the engineer of tomorrow? What thought are we giving to him? Engineers appreciate that by their example, as well as by their encouragement and active help given to educators and to the engineering novitiate, they are building the foundations of the profession more firmly and raising it ever higher. They know that education for useful living is not completed in college. It continues throughout life.

Our Institute, representing the electrical section of American engineers offers the fellowship of kindred souls, a broadening of outlook and of knowledge, a blending of humanism with technology. It carries inspiration to its members to be not only technicians of high order but also trained seekers of the needs of mankind, applying their skill and their knowledge to the end that life for the teeming millions of their fellowmen may be made more worth while, less burdensome, more healthful, and more noble.

Thus, my friends, do I conceive the true engineer,—one, who in thought and deed, is and ever will be a practical idealist.

Abridgment of

Safe Loading of Oil-Immersed Transformers

BY E. T. NORRIS[1]

Member, A. I. E. E.

Synopsis.—An attempt is made to describe simply and clearly the basis of the temperature rating of oil-immersed transformers and the relations between the temperatures measured in service, the maximum safe output rating, and the national standard ratings.

A description is given of an instrument for indicating the safe output rating of a transformer in service under any conditions of short time or continuous loading.

* * * * *

LIST OF SYMBOLS

A = Temperature of cooling medium—usually air or water.
D = Maximum variation in temperature of the circulating oil.
G = Maximum winding temperature difference.
Ga = Average winding temperature difference.
H = Hottest spot temperature.
h = $H - A$.
K = Constant.
N = Ratio copper to iron loss at full load.
P = Load on transformer as a fraction of full load.
R = Average temperature of the winding by resistance.
r = $R - A$.
T = Hottest oil temperature.
t = $T - A$.

As the load current in an oil-immersed transformer is increased, its temperature rises due to the increase in losses. One limit to the load which may be taken from a transformer is set, therefore, by the maximum temperature permissible.

BASIS OF OUTPUT RATING

The material most susceptible to damage by heat in a transformer is the insulation. The fundamental basis of the rating of the transformer is therefore the maximum temperature the insulation will safely withstand. The temperature of the hottest part of the insulation of the transformer (or the hottest spot temperature H) must never be allowed to exceed this safety limit.

The limit applies, of course, to the insulation both in the core and in the windings. Since, however, the core losses are practically constant for all loads whereas the copper or winding losses increase rapidly with the load, it is the winding insulation which is most affected by the loading, and its hottest spot temperature which determines the safe maximum load.

If it were possible to measure the hottest spot temperature while the transformer was in operation, it would be a simple matter to determine the maximum safe rating and to insure that it would not be exceeded. Unfortunately, except in a few special instances, there are no known practical means of measuring this temperature directly.

As a rule it is not possible to employ thermocouples or other forms of embedded temperature detector in such a way as not to weaken the transformer insulation and yet record accurately the true hottest spot temperature and be safe in operation. This position has recently been confirmed at a meeting of the International Electrotechnical Commission.

The most useful practical temperature measurements are:

a. The temperature of the hottest oil by thermometer = T.

This temperature is easily measured and a continuous record can be obtained while the transformer is in service. It however does not follow closely short-time load variations.

b. The average temperature R of the windings calculated from the resistance.

This measurement is mainly suitable under testing conditions. It is necessary to disconnect the transformer in order to measure the resistance, so that readings cannot be obtained during operation. The temperature measured is the average temperature of the whole winding.

To determine the maximum safe rating of a transformer from these two temperatures, it is necessary to know the relations between these temperatures and the hottest spot temperature.

STANDARD OUTPUT RATINGS

It is important to distinguish between the true thermal rating of a transformer and its rating in accordance with a standard specification.

The true thermal rating is determined by the maximum safe hottest spot temperature. It is not a constant for a given transformer but may have any value depending on the conditions of loading and cooling.

The primary purpose of a national standard specification is to provide a basis for the comparison of transformers of different makes and types. The standard rating must be so defined that it can be determined easily and accurately in practise, and is therefore expressed in terms of the observable temperatures, R

1. Chief designer, Ferranti, Ltd., London, England.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

and T. It is based on certain definite loading and cooling conditions so as to be a constant for a given transformer.

The manner in which the observable temperatures R and T are derived from the hottest spot temperature for standardization purposes is explained in Pamphlet No. 1 of the A. I. E. E. Standards.

For the standards of three countries, typical values of these observable temperatures, after continuous rated load, are given in Table I. The standards specify both these limiting temperatures and state that neither may be exceeded.

TABLE I

Country	Self-cooling		Forced-cooling	
	R	T	R	T
U. S. A.	95	90	80	..
Britain	95	90	90	75
Germany	105	95	..	..

Typical values of the cooling medium temperature A, together with the resulting temperature rises, are given in Table II.

TABLE II

Country	Self-cooling			Forced-cooling		
	A	r	t	A	r	t
U. S. A.	40	55	50	25	55	..
Britain	40	55	50	25	65	50
Germany	35	70	60	..	..	..

The loading and cooling conditions chosen by all the standardization authorities are extreme. The British and American standards, for example, assume full load continuously, and an ambient air temperature of 40 deg. cent. continuously for self-cooled transformers—operating conditions which are rarely encountered in practise.

An apparent advantage of this basis is that the standard rating is very conservative and may safely be worked to in almost any climate and under any loading conditions.

It has become general practise for operating engineers to consider the standard rating as being the maximum safe rating under normal working conditions. Transformers much larger than necessary are therefore installed.

A relatively minor disadvantage of this position is waste in transformer plant installed and in exciting kv-a. and losses.

A more serious result is that operating experience cannot distinguish between transformers of good and bad thermal design. Undesirable opportunity is thereby given to the unskilled or unscrupulous manufacturer, and lessons of experience which are essential to progress in design and construction are lost to the industry.

It is suggested that the use of hottest spot temperature indicators be encouraged in standard specifications, that distinction be made between the true thermal rating and the standard rating as described earlier in the paper, and that alternative standard ratings be recognized covering more practical operating conditions.

WINDING THERMAL CONDITIONS

A transformer winding with oil flowing through it is shown diagrammatically in Fig. 2. The temperature T of the oil leaving the windings is here assumed to be the same as the temperature of the hottest oil. This is so in most practical cases. Where the difference is appreciable, however, an average value can be assumed which will give sufficiently accurate results for the present purpose. The same conditions apply to the increase of oil temperature D.

The temperature of the oil at the bottom of the windings will be $(T - D)$.

The relation between the winding temperature at any point and the adjacent oil temperature depends largely upon which of the following conditions holds:

1. The direction of oil flow at right angles to the conductors in the winding.
2. The direction of oil flow parallel with the conductors in the winding.

Condition (1) applies to most core type and some shell type transformers.

Condition (2) applies to many shell type transformers.

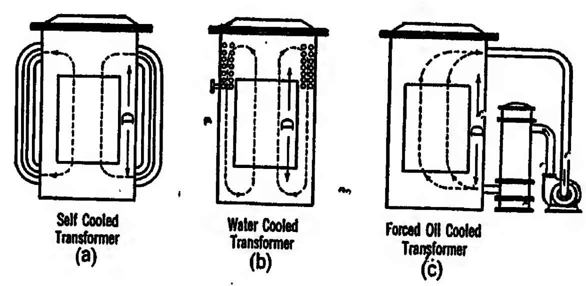

FIG. 1

Under condition (1), considering only a steady continuous load and assuming the windings are fairly symmetrical, the hottest spot temperature of the insulation at any point such as a or b in Fig. 1 will be a constant value G above the adjacent oil temperature. The hottest spot temperature of the copper, and therefore of the adjacent insulation at c, for example, will be $(T - D + G)$.

The hottest spot temperature H of the copper for the whole winding will be at some point b and such that

$$H = T + G \tag{1}$$

This temperature H must not exceed under any conditions of loading the safe limit; *e. g.*, 105 deg. cent. for I. E. C. rating.

Under condition (2), the thermal gradient in the winding in the direction of the conductors will be short-circuited by the copper, since the thermal conductivity of copper is approximately 2000 times that of the winding insulation. The temperature of the winding will be constant in the direction parallel to the flow of the oil. Then the winding temperature difference

will not be constant as in the previous case. At the top of the windings it will be $(H - T)$, and at the bottom, $(H - T + D)$. If G is the value at the top of the windings, then

$$H = T + G$$

as in Equation (1).

The temperature R measured by increase of resistance of the windings will be the average temperature of the copper in the windings taking the average in directions both normal and parallel to the flow of oil.

Under condition (1) its equivalent is the temperature of the copper at some point near the center of the winding such that:

$$R = T - K\,D + G_a \qquad (2)$$

For condition (2) the temperature of the copper is constant at all points in a vertical direction. Assuming G_a is the average value of the winding temperature difference at the top of the windings, then:

$$R = T + G_a \qquad (2a)$$

Comparison of this relation with Equation (2) shows

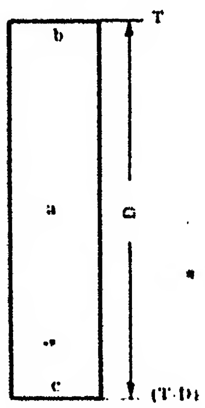

Fig. 2

that if the flow of oil is parallel to the conductors, K becomes zero.

It should be noted, however, that in practise, the direction of oil flow cannot be parallel to the conductors for the whole of the winding. The temperature relations for condition (2) will therefore apply to only part of the winding, and for all types of transformers K will be greater than zero.

It is now possible to estimate the affect on the permissible loading of variations in the temperature of the cooling medium. The method can be most clearly shown by an example.

Consider an A. I. E. E. rated self-cooled transformer with the following thermal characteristics after continuous full load with an ambient air temperature of 40 deg. cent. These values are typical of a medium sized self-cooled core type transformer.

$R = 95 \quad D = 20 \quad G_a = 18 \quad G = 20$

$T = 85 \quad H = 105 \quad K = 0.4$

Ratio of copper to iron losses $= N = 2$

Equation (2) becomes $95 = 85 - 8 + 18 \qquad (7)$

Equation (1) becomes $105 = 85 + 20$

Suppose the ambient temperature is only 25 deg. cent. At full load $R = 80$ deg. cent., $T = 70$ deg. cent., and $H = 90$ deg. cent. The load may safely be increased until H is raised to 105 deg. cent.; *i. e.*, h may increase to 80 deg. cent.

Let P = the new permissible load as a fraction of normal full load

The new total losses will be $\dfrac{P^2 N + 1}{N + 1}$ times normal.

The new copper losses will be P^2 times normal.

Equation (4) becomes:

$$80 = \frac{2\,P^2 + 1}{3} \times 45 + 20\,P^2$$

whence $P = 1.14$

Hence the effect of reducing the ambient temperature from 40 deg. cent. to 25 deg. cent. is to increase the output rating of the transformer 14 per cent.

At this overload, with an air temperature of 25 deg. cent., the hottest spot temperature will be 105 deg. cent. and Equation (2) will read

$$92.8 = 79 - 9.6 + 23.4 \qquad (8)$$

It is instructive to compare (7) and (8). Both the hottest oil and winding temperatures are lower in the second case, but the transformer is equally loaded thermally in the two cases.

The formulas developed in this paper are intended for purposes of illustration and exposition rather than for actual application to practical problems.

The predetermination of the true thermal rating of transformers requires numerous formulas to cover the wide range of loading and cooling conditions that may occur in practise. None of these formulas would be sufficiently general to be suited to the present purpose. The complete subject has been treated recently by the present author.[2]

Relation Between Oil Temperature and Output Rating

The hottest oil temperature is easily measured on a transformer in service, and it is well, therefore, to examine whatever information as to the loading conditions can be obtained from it.

From Equation (10) $P = \sqrt{\dfrac{H - T}{G_n}}$ where H and T are values at load P, and G_n is the winding temperature difference at normal load.

In the example $G_n = 20$

Hence $P = \sqrt{\dfrac{105 - T}{20}}$

This relation is plotted in a curve in Fig. 4. The practical use of the curve has been pointed out by

2. "Thermal Rating of Transformers," *I. E. E. Journal* (England), Vol. 66, No. 380, p. 841.

G. L. Porter. It gives the maximum oil temperatures for different loads. If, for instance, in the example the load is 120 per cent, the oil temperature must not be allowed to exceed 76.2 deg. cent. Whether the transformer is able to carry this load continuously depends on the air temperature. Equation (9), or Fig. 3, shows that for this to be possible, the ambient temperature must not exceed 18 deg. cent.

The curve may be applied to temporary overloads as well as to continuous loads. For instance, an overload of 30 per cent in the example may be applied until such time as the oil temperature reaches 71.2 deg. cent.; and this is true no matter what the previous loading conditions, if within the safe rating; *e. g.*, whether the transformer has previously been on full normal load or even on no-load.

If the air temperature is greater than 5.5 deg. cent. (Equation (9) or Fig. 3), it is only a matter of time before the oil temperature reaches 71 deg. cent. When this happens, the load must be reduced. This use of Equation (10) gives results slightly on the safe side for short time heavy overloads of only a few minutes' duration, since it makes no allowance for the thermal time constant of the windings.

Again, suppose at a given instant, the oil temperature

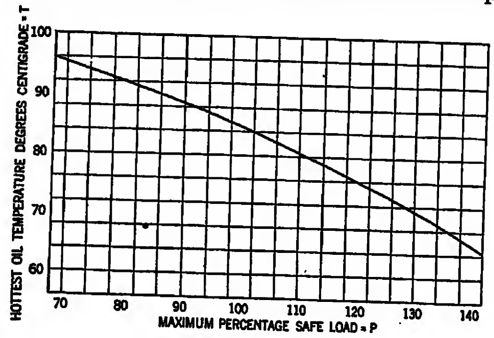

Fig. 4

of this transformer is 75 deg. cent. but the previous loading history is unknown; the curve states that any load up to 122 per cent may safely be taken from the transformer. (Actually some margin should be allowed here and a somewhat lower limit than 122 per cent assumed). How long this load could be taken depends upon the air temperature, but always so long as the oil temperature does not exceed 75 deg. cent.

The curve also shows up the possible danger of oil temperature alarm protection. Suppose, in the example, the oil thermometer were set to operate an alarm when the hottest oil temperature exceeded 80 deg. cent, Curve 4 shows that the alarm would be given quite unnecessarily so long as the load were below 112 per cent. On the other hand, the transformer might be carrying a load greater than 112 per cent and greater than the maximum safe limit (*i. e.*, with a hottest spot greater than 105) without the alarm functioning.

In some countries, it is common for oil alarms to be set at 90 deg. cent. In the example referred to, representing an average oil-immersed self-cooled transformer, if the air temperature were 30 deg. cent. and the transformer were overloaded 20 per cent continuously, the hottest oil rise would be 58.2 deg. cent. and the hottest oil temperature 88.2 deg. cent. The alarm would therefore not function, although the hottest spot temperature would be 117 deg. cent. and the transformer loaded beyond the safe limit.

These illustrations show the numerous practical uses of a curve such as Fig. 4.

Transformer Safe Load Indicator

It has been shown that the hottest oil temperature is misleading as a guide to the safe loading of a transformer and that the true criterion is the hottest spot temperature within the windings. Instruments for measuring indirectly this hottest spot temperature have been developed in various forms by many transformer manufacturers.

In principle, the components T and G from Equation (1) are measured separately. T is measured directly and G is obtained indirectly through the relation between it and the load current in the windings. A current transformer is therefore necessary and may be connected on either primary or secondary side of the main transformer.

Such instruments show clearly whether the transformer is fully loaded and will actuate an alarm or close a relay tripping circuit when a dangerous condition is being approached.

By calibrating an instrument of this type in percentage of maximum safe load instead of in hottest spot temperature, the information given by the curve Fig. 4 and illustrated by the examples previously described can be indicated directly. Inspection of Equation (10) shows that the variable factors are P, the load on the transformer, and T, the hottest oil temperature, both of which are already used in the hottest spot temperature indicator.

With this calibration the instrument shows directly:

1. The existing load as a percentage of the maximum safe load—showing how much of the permissible output rating is being utilized.

2. The maximum load on the transformer during any desired period expressed as a percentage of the maximum safe loading. If, for instance, this record were 75 per cent over a period of 24 hr., it would mean that at no time during that period did the load on the transformer exceed 75 per cent of its available capacity.

The formula assumes that when any given load is switched on, the winding temperature difference G reaches the value corresponding to that load immediately. This assumption underestimates the overload capacity of the transformer by a few minutes' duration of load. This is a desirable characteristic, in that for rapid and dangerous increases in load, warning will be given a short time before the danger point is actually reached.

Since the standard rating of a transformer is based

on continuous loading and on an abnormally high cooling medium temperature, the true rating under the normal operating conditions of discontinuous loading and comparatively low cooling medium temperature will be considerably greater than the standard rating.

By means of the safe load indicator, the true thermal rating under operating conditions may be fully utilized, and a corresponding saving made in capital cost of transformer plant installed and in exciting kv-a. and losses.

Abridgment of

Analytical Determination of Magnetic Fields

Simple Cases of Conductors in Slots

B. L. ROBERTSON* and I. A. TERRY†

Associate, A. I. E. E. Associate, A. I. E. E.

Synopsis.—In this paper, La Place's and Poisson's equations are applied to cases of current-carrying conductors in rectangular slots to show the flux distributions which obtain.

The paper first treats with the general case which is a single conductor, completely surrounded by insulation, at the bottom of a slot. Next is taken up the more practical case of a slot containing two insulated conductors, one above the other, in which currents of equal magnitude are considered first to flow in the same direction, and then in opposite directions.

In addition to these analyses, a few special cases are discussed. Methods by which the flux distributions in slots containing an even number of coil sides may be obtained, or in slots the conductors of which carry currents not in time-phase, are also discussed. Equations are developed from which all of these fields can be calculated.

A discussion is included to show the distribution of flux on the assumption that the lines go straight across the slot, and a comparison is made between the slot inductance determined mathematically from the equations developed and by the usual design formulas. In the case considered it is found that the design formulas give a value of slot inductance which is about 96 per cent of that obtained by the mathematical treatment, which is within limits of engineering accuracy. An expression is developed which shows the error that may be expected in any particular case.

* * * * *

I. Introduction

Within the last few years several papers have been presented before the Institute, and articles have been published in various technical journals on the theory and practical applications of flux plotting. It has been shown that if they are devoid of current, quite accurate flux plots can readily be made free hand for many geometrical figures, about the only fundamental requirement being a knowledge of the potential difference between the various boundaries of the configuration. Although the problem is greatly complicated in current-carrying regions, methods have been outlined for free-hand mapping of fields under these conditions, and can be applied very well whenever the general arrangement of the lines of force is known in advance. If the general field arrangement is unknown, then a great deal of sketching and resketching must be done in order to obtain a correct plot; and often much labor can be saved by deriving, analytically, the equations for the lines of force and then plotting the loci of these equations.

Several years ago, W. Rogowski solved La Place's and Poisson's equations for the case of a pancake type of transformer, analytically determining the magnetic field distribution about the windings. An excellent translation of Rogowski's work was given by Doctor A. R. Stevenson, Jr.,[1] in 1926. Shortly after that, Messrs. Stevenson and Park[2] showed the application of the analytical method of determining the flux distribution about the field pole of a definite pole machine, including in their discussion several other figures which are of theoretical interest. Cases of conductors in slots have also been treated with,[3] but there the solution results in a series which converges so slowly that the task of plotting the field is laborious.

In this paper, analytical expressions are developed for plotting the flux about rectangular conductors in rectangular slots by use of the method originally employed by Rogowski. Flux plots are shown for a number of different locations of a single conductor in a slot, and for the practical case of two conductors, one above the other in the same slot. The mathematical expressions are in the form of a series that converges very rapidly, thus simplifying the problem of making the plots.

In addition to the above, a comparison is made between the slot inductance determined (a) by the usual design formulas, (b) by mechanically integrating the mathematical flux plot to obtain the flux linkages, and (c) directly from the R-equations.

From the latter, a simple expression is obtained for use in design formulas to give the increase in induc-

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1. Reference at end of paper.
2. See reference (2).
3. See reference (5).

tance due to the curvature of the flux lines over the inductance determined on the usual assumption that the lines of force are everywhere parallel to the bottom of the slot.

II. Fundamental Equations

As a general example, in Fig. 1, which represents an insulated rectangular conductor at the bottom of an infinitely deep slot, it is assumed that:

1. The permeability of the air, insulation, and copper is unity.
2. The permeability of the iron is infinite. (These two assumptions mean that the flux must enter the iron at right angles to the surface).
3. The conductors are subdivided, thus eliminating

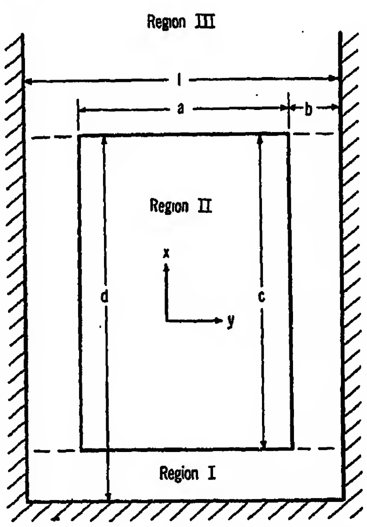

Fig. 1—General Case of Conductor Completely Insulated from Slot

skin effects and resulting in uniform current density.

Rogowski developed the conception of dividing the slot into regions, satisfying either LaPlace's or Poisson's equations; then, by considering each region separately, the current distribution may be represented by a single dimension Fourier series, and the problem greatly simplified.* The single dimensional Fourier series may be chosen to represent the current in the one slot only, but another simplification is made possible from the application of the method of images.

It is well known that with a conductor near an iron surface of infinite permeability it is possible to replace the iron surface by a conductor, called the image of the first, carrying current in the same direction. Similarly, a slot may be replaced by its image on both sides and below, (see Fig. 2), the first group of images being re-imaged, etc. Due to the fact that the slot is open at the top only a double row of images exists, which then replaces the original conductor and slot, and gives rise to a periodic reactangular current distribution, the Fourier series of which can readily be obtained.

The total field of the slot of Fig. 1 is divided into three distinct regions:

Region I. Air district between the images formed by the bottom of the slots and the bottom of the conductors.

Region II. District occupied by the conductors in a horizontal row including the air or insulation spaces between the conductors.

Region III. The air and insulation space above the conductors.

Region I, having no currents, satisfies LaPlace's equation,

$$\frac{\partial^2 R}{\partial x^2} + \frac{\partial^2 R}{\partial y^2} = 0 \qquad (1)$$

Region II, being a district of currents, must satisfy Poisson's equation,

$$\frac{\partial^2 R}{\partial x^2} + \frac{\partial^2 R}{\partial y^2} = -4\pi I \qquad (2)$$

VI. Slot with Two Conductors

The slot containing two conductors, completely insulated from each other and from the iron walls of

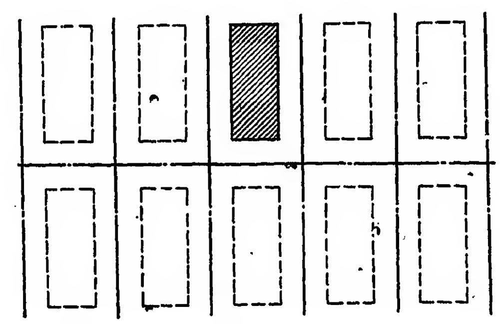

Fig. 2—Images of a Current Carrying Conductor in an Infinitely Deep Slot in Iron

the slot and placed one above the other, is typical of synchronous machine design and therefore forms one of the most practical application of flux plotting by the mathematical method.

In the solution of this problem, the entire field is divided into five regions, (Fig. 12). The air regions satisfy LaPlace's equation, Equation (1), and the current carrying regions satisfy Poisson's equation, Equation (2).

In the general case previously discussed, it is obvious that the magnetic field for the single conductor in any certain configuration will always yield one type of plot. Its form will be altered only by slot and copper dimensions, but will not be affected by the magnitude of the current. The direction of flow of the current will, of course, change the direction of the lines of flux.

The solution of this problem, however, brings into

*Herein lies the main difference between the present analysis and that of E. Roth, (reference 5), who used a two dimensional Fourier Series.

consideration the direction of the flow of current in the conductors; that is, whether or not the current in the upper coil side is flowing in the same direction as the current in the lower coil side. Furthermore, the relative magnitudes of these currents are important

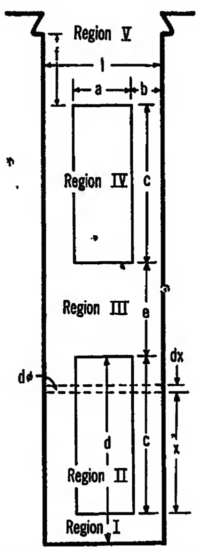

FIG. 12—SLOT WITH TWO CONDUCTORS

because for each ratio of the two densities there exists a distinct field. An infinity of flux plots is thus the complete answer to the problem. Although any one of these plots can be determined accurately, it is within the scope of this paper to discuss fully only two important types, and to indicate the solution for any other set-up.

The illustration first treated here is that in which the two conductors carry equal currents in the same direction. Similar to that shown in Fig. 2, the current-carrying regions will now be represented by two infinite series of reflected and re-reflected images, one above the other. Each region has its own Fourier series for the current density, and since the density is the same for each group of images; the Fourier series is the same for each region and is of the form given by Equation (8).

The form of the function R is as it was before, and from its substitution in Equations (1) and (2) are obtained the two sets of relations given by Equations (1b) and (2b). The first set of relations now holds for Regions I, III, and V, since they carry no current, while the second group holds for Regions II and IV, the current-carrying districts. The general solutions for R and the constants for these equations are obtained in like manner to the ones detailed in Section II of the paper. It is necessary now to solve simultaneously the five sets of regional solutions in order to determine the coefficients A_0, A_n, . . . etc. The reader is referred to Appendix D for the complete mathematical analysis.

The numbers to the right of Fig. 13 were obtained by calculating the flux on the basis that it crosses the slot in straight lines. It makes little difference in the values of total flux above the lower conductor, as indicated by the results.

The case in which the conductors carry equal currents, but flowing in the opposite direction, is considered next. Whereas both currents in the previous illustration were flowing in a negative direction,—that is, up out of the figure,—the upper current will now be assumed to flow positively. Within this reversed current district, Region IV, Equation (2) must be altered to read,

$$\frac{\partial^2 R}{\partial x^2} + \frac{\partial^2 R}{\partial y^2} = + 4 \pi I \qquad (17)$$

f I, the current density expressed as a Fourier series, is to be the same as it was before. If, however, I is changed in sign, then Equation (2) still will hold. The final regional expression for the upper conductor contains a change of sign before the term including α_n. Such a condition calls for a new determination of all of the coefficients in the regional equations because these relations must be solved simultaneously. The analysis for this case is given in Appendix E.

Fig. 14 illustrates the field about the same two conductors of Fig. 12, the upper current now being reversed. At the bottom of the slot, and well up the sides, the flux plot is practically dependent only on the lower conductor because of the extremely weak field in that region produced by the reversed current above. Within

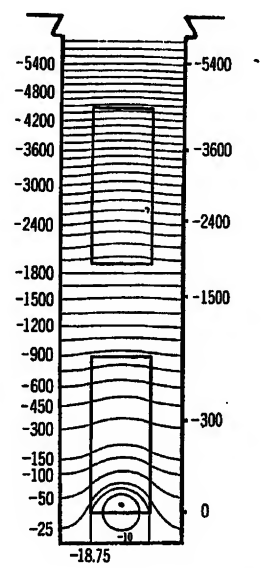

FIG. 13—FIELD ABOUT A TWO-CONDUCTOR SLOT
Currents in the conductors equal and in the same direction

in the upper copper; however, the lines rapidly change their shape, eventually closing within the slot about a second kernel.

Fig. 15 shows in detail the field about the second kernel. Immediately about the kernel the flux travels in approximately elliptical paths, the outer approaching the slot walls and closing upon themselves at very

great distances. Beyond this group of lines the flux strikes the sides of the slot. These plots verify those determined graphically by Calvert and Harrison.[4]

Flux plots for armature slots of a synchronous machine are necessarily dependent upon instantaneous values of current, except for pull-pitch coils. In these instances, the currents in the conductors bear a constant relation to each other. The field plot will then have the same conformation although a changing magnitude of total flux. In actual practise, full-pitch windings

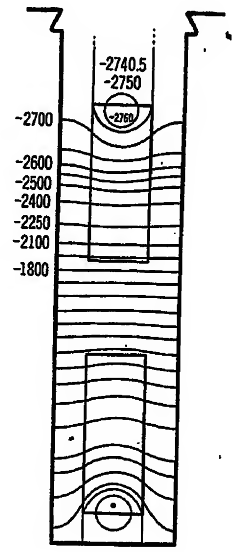

Fig. 14—Field About a Two-Conductor Slot
Currents in the conductors equal but in opposite directions

are seldom used, the usual design being somewhere near ⅔-pitch armature coils. The currents in the upper and lower conductors now differ in time-phase,

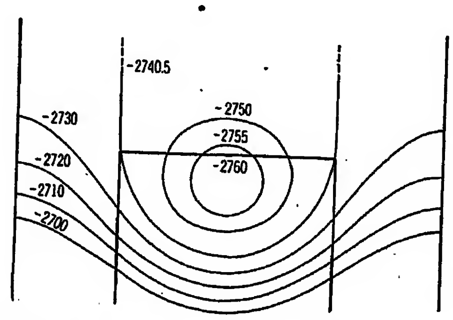

Fig. 15—Detailed Field Showing Whirl of Flux About Top of Upper Conductor of Fig. 14

and for each instant of time there corresponds a new flux plot.

The method by which a field map may be made for any ratio of conductor currents is very simply outlined. The only important step is to adjust the signs of the Fourier series for the current densities of Regions II and IV. For currents in the same direction both series will have the same sign which will depend upon the direction of the current flow. For opposite currents the series will then of course have opposite signs. Substitution of these current density forms in the regional equations will automatically care for all algebraic signs which follow.

VII. Inductance Comparison

One of the most important applications of flux plotting is the determination of the inductance of a current-carrying system. To illustrate the method, the inductance of the conductors in the slot under consideration has been determined. In a paper recently presented to the Institute by Mr. P. L. Alger,[5] a very complete discussion was presented on the leakage reactance of the armature winding of a synchronous machine. In his paper, slot-leakage inductance is calculated by assuming that the flux lines in the slot

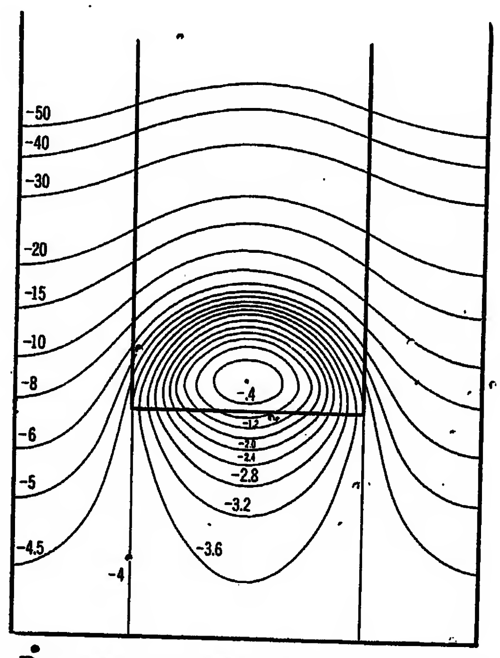

Fig. 17—Detailed Field of a Conductor Showing Whirl of Flux about Kernel

go straight across. This, of course, involves an error because the curvature of the lines as seen in the plot of Fig. 13 is such that a given flux will link more current than if the flux goes straight across the slot; therefore, the exact method will give a larger reactance. However, the amount of error due to the approximation will be seen to be so small as to be negligible. The reader is referred to Appendix E for the derivations of the inductance formulas.

The following tabulation shows the various components of inductance as determined graphically, by mechanical integrating the flux plot, and analytically, under the assumption that the flux lines go straight across the slot. This analysis has been carried only to the bottom of the wedge, (Fig. 12).

4. Reference (4).

5. Reference (3.)

Region	Inductance in (Abhenrys)/N^2 Present approximations	Mechanical integration of Fig. 13
II	0.150	0.138
III	0.250	0.250
IV	1.005	0.950
V	0.758	0.753
	2.163	2.091

This comparison shows an increase of approximately 3.5 per cent in the inductance determined from the mathematical flux plot. Such an increase is very reasonable, since the assumption that the flux lines go straight across the slot is in error to some extent in regions near the bottom of the slot. This is shown in the figure, the values on the outside of the slot indicating the flux determined on this basis.

In Appendix G the inductance of the two conductor slot is determined mathamatically from the vector potential R. The expression therein derived shows directly the magnitude of the correction term which gives the increase of inductance due to the curvature of the flux lines above the inductance calculated on the assumption that the lines of flux go straight across the slot. By the omission of insignificant terms the correction term becomes

$$L' = \frac{l^3}{c^2 a^2 \pi^3} \left(c - \frac{l}{2\pi} \right) \sin^2 \frac{a\pi}{l} 10^{-9} \text{ henrys per } N^2 \tag{18}$$

This is simple enough for use in design formula wherever it affects the accuracy to an appreciable extent.

For the slot of Fig. 13.

$$L' = 0.087 \times 10^{-9} \text{ henrys per } N^2$$

or an increase over that obtained by Equation **(12f)** of about 4.1 per cent.

This agrees with the increase in inductance obtained from the flux plot, being slightly higher because the mechanical integration of the flux plot is limited to finite increments whereas the mathematical method deals with infinitesinal increments.

VIII. Detailed Plots

The flux plot of Fig. 17 has been made for general interest, to show in detail the field about the kernel of a conductor. The distance between the lower face of the conductor and the slot bottom was made great enough to bring out the whirl of flux in a pronounced manner.

Summary

The usual types of rectangular slots met in practise have been considered, and the general method of attack has been given in sufficient detail to make its application to other examples quite clear and straightforward. The general equations will have been developed may be applied to any slot by simply substituting for the particular dimensions involved.

The error in inductance calculated on the assumption that the flux tubes go straight across the slot has been shown to be small enough to be negligible in usual slots met in practise, thereby indicating that present assumptions give sufficiently accurate results for engineering purposes.

Acknowledgments

The authors wish to express their appreciation to L. P. Shildneck for the development of Appendix A of the paper, to Doctor E. J. Berg of Union College for his kindness in reviewing the manuscript and offering valuable comments, and to Mr. R. E. Doherty for his helpful suggestions.

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ENGINEERING SOCIETIES EMPLOYMENT SERVICE

EXCERPTS FROM LETTERS OF APPRECIATION

April 29, 1929.

Please find enclosed a check .... as a payment to the Engineering Societies Employment Service for its prompt and efficient service in placing me with the .... corporation. I was accepted immediately upon the first interview.

January 5, 1928.

We have engaged two previous men sent from your Department and returned the cards to your office. So far these men are working out satisfactorily and we wish to thank you for your helpful interest.

January 3, 1928.

It is unfortunate but true that most of your applicants are of a much better grade than we can use at the present time.

We wish to thank you for your kind and efficient attention to our request for men and are returning to you such applications as were sent to us for our approval.

August 9, 1928.

Just a note to thank you for your letter of yesterday with the attached records of 1928 electrical engineers. Our transmission Engineers will go over these today, after which I shall communicate with you, returning the records to you at that time.

We appreciate not only what you have done, but the fine spirit with which you did it.

Abridgment of

Telephone Transmission Networks

Types and Problems of Design

BY T. E. SHEA[1]
Associate, A. I. E. E.

and

C. E. LANE[1]
Associate, A. I. E. E.

Synopsis.—A brief résumé of the nature of telephonic signals is given, showing how the qualities of wave composition which distinguish signals from other electrical waves set the requirements on networks and provide a basis for their design.

The principal functions of wave filters, equalizers, telephone transformers, line balancing networks, and artificial lines are outlined. In order that these networks may be used in conjunction with other apparatus in the telephone system, they must provide efficient transmission, low distortion, good impedance balance, stoppage of longitudinal currents, stable characteristics with current variations, low external coupling, and low reflection coefficient. In addition to these requirements, the network must not cross-talk into associated circuits and must have desirable impedance characteristics in the attenuation range of frequencies as well as throughout the transmission range.

An illustration of the use of transmission networks in a typical three-channel carrier telephone system is given describing the functions of the line filter sets, the directional filter sets, band filters, and equalizers.

Some of the engineering limitations on the design and construction of networks are discussed.

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THE past 30 years have witnessed many important developments in electrical communication. Looking back, it appears almost as though the various dynamic sciences which had rapidly grown in scope under influence of Maxwell, Helmholts, and others, having been for a time pent up, were fairly bursting in their eagerness to spill over into the communication field innumerable facts capable of being put to great practical use. The writings of Heaviside are clear evidence of the transition, pointing to many useful relationships while making important advances in electrodynamics.

Subsequently, striking applications of the new knowledge as typified by inventions and discoveries went constantly hand in hand with a codification or systematization of the knowledge found useful. Thus, paralleling the origination of the loading coil by Pupin, the thermionic vacuum tube by De Forest, and the wave filter by Campbell has been the systematizing work of Campbell, Kennelly, Blackwell, and others. Out of the latter process has grown what is often called "telephone transmission theory." One of the most important and striking branches of "telephone transmission theory" is that which relates to the properties of electrical networks used for transmission purposes, and called *transmission networks*.

Space is not available here to enter into a complete discussion of the uses to which transmission networks are put, and for purposes of illustrating such uses, we may confine ourselves to largely to certain aspects of long distance telephony. This choice of illustration will serve perhaps better than any other to bring out the physical and economic attractions which the networks can have for engineers.

Long distance circuits are of various kinds. There are open wire,[2] cable, and radio facilities. These impose very different requirements on apparatus used in transmission. From an electrical standpoint, they may provide telegraph, normal telephone (both side circuit and phantom circuit),[3] superimposed carrier current (telephone and telegraph), telephotograph, and radiotelephone transmission.

The length of the circuits, together with the high standards of transmission they require, and the desirability of employing them intensively by multiplexing messages, means careful consideration of the fundamental factors influencing transmission and of the numerous functional objectives which component apparatus must attain. This is particularly so if the service provided is to have universal standards, regularity of operation, and low costs of maintenance and operation.

With this situation in mind, we may consider in some detail just what the manifold functions of typical networks are. The functions necessarily divide themselves according to what they have to do (1) with the primary purposes of employing the networks, and (2) with the conditions to be met by networks as integral

1. Both of the Bell Telephone Laboratories, New York, N. Y.
Presented at the Regional Meeting of the South West District No. 7, of the A. I. E. E., Dallas, Texas, May 7-9, 1929. Complete copies upon request.

2. *Open-wire facilities* are those whose circuits employ wires separately strung overhead on pole lines, in contrast to *cable facilities* which use wires from among those provided by a cable. The electrical characteristics of the two types of circuits are generally quite different.

3. *Normal telephone transmission* is that which uses directly the ordinary frequencies of speech and music. In carrier-current transmission, a modulation is employed in order to permit using a different range of frequencies for transmission purposes. (See Section 4.)

A phantom circuit is one which straddles two pairs of wires, one pair acting as a conductor in either direction. In this case, each pair is also used for transmission in which one wire of the pair works in one direction and one in the other. Each of the pairs is said to comprise a side circuit and to afford side circuit transmission.

parts of systems, working harmoniously with other apparatus. As a prerequisite to such a discussion we shall start with a survey of the ideals of signal transmission.

Only the more important types of transmission networks will be mentioned. These are; *wave filters, equalizers, telephone transformers, line balancing* (*i. e., simulating*) *networks*, and *artificial lines*.

I. Signals and Their Transmission

Signals, whether of systems of telephony (carrying speech and music), telegraphy, or telephotography have qualities of wave composition which differentiate them from other electrical waves. These qualities determined largely the performance required of networks which aid in their transmission, and thus provide much of the physical basis of transmission network design methods. From the purpose and circumstances of signals, it is obvious that they are essentially of a *temporary* character. They are used at a particular time to convey information and they cease as soon as their message has been transmitted. We may consider as pertinent examples of this, articulate speech, music, and telegraph signals.

Consequently, even the most elementary of signals, such as a "single-frequency tone," maintains an approximate steady state merely for a limited period. Such elementary signals can be used to convey only a very small number of different ideas. For the free interchange of ideas through signals, we must employ either a complex code of artificial groups of signal elements to represent the characters of a written language, or the much more complex signal elements (vowels, consonants, and notes) required in spoken language and music.[4] Because of economic considerations, in the case of telegraphic signals, the duration of pulses and time between is made so short that the transient state predominates, so that the distinguishing characteristics are largely transient in character. In the case of speech and music, owing to changes in expression much of the distinguishing characteristics are also transient in character. To put it another way, the envelopes of the waves *modulate with time* the characteristic frequencies which the sounds, if sustained, would tend to possess, and have an important bearing on the meaning conveyed by the signal. Preservation of these envelopes is a matter of transient state transmission. But transient states really involve the transmission of steady state frequencies grouped as *continuous bands* along the frequency scale. *Preservation of the entire content of a signal therefore involves consideration of the transient properties of networks; i. e., involves their steady-state properties over a somewhat w ide frequncy range.*

The imperfections which may creep into the transmission of signals may be classified under three headings: improper signal *volume*, *distortion* of signal content, and *interference* by waves foreign to the signals; that is, if waves are received of appropriate intensity, if the important frequency ranges are uniformly transmitted, and if nothing but the desired waves are received, the ideals of transmission will have been realized. Waves may be so strong as to cause physiological difficulties in reception, or so weak as not to be recognized. This means that efficiency of transmission is an important factor although, when amplifiers are used, partly an economic one. Signal distortion is of two kinds—*amplitude distortion* and *phase distortion.* Amplitude distortion arises from the transmission of different frequencies with unequal efficiencies and is highly important in all types of signals, but its aggregate importance depends on the importance of the frequency components that are efficiently transmitted. Phase distortion results from different frequencies traveling with different velocities such that their relative arrival times differ from their relative starting times. It is ordinarily less important in the transmission of speech than in other kinds, but the accumulation of phase distortion which may occur on long telephone circuits gives rise to undesirable transient effects. Interference may be of two kinds: It may arise from the introduction of energy into the communication circuit from outside, through electrostatic or electromagnetic coupling, or it may result from the imperfect separation of several simultaneously transmitted signals or from the generation of extraneous frequency components through modulation.

These three types of imperfections should be kept in mind in considering the functions of different types of transmission networks.

II. Principal Functions of Transmission Networks

The principal functions of the more important types of networks may be described as follows:

Wave Filters

It is characteristic of telephonic signals that their transmission requires the use of a continuous band of frequencies whose width may be perhaps 2000 cycles as a minimum and 6000 cycles as a maximum (both approximate). Where, as an example, due to economic factors it is desirable to transmit simultaneously two or more telephonic frequency bands, whether this be done entirely conductively along wires or partly by radiation through space, discriminating means are required to make the transmission of a particular communication channel efficient to that band, or those bands, of frequencies which are desired, while rendering the circuit highly inefficient at other frequencies. To put this in

4. The signals corresponding to pictures resolved for transmission purposes are somewhat similar in form to telephone and telegraph signals. On the other hand, depending on the speed at which they are sent, they may require the use of a frequency range greater even than that of speech or music.

In connection with this section see "Transmission of Information," by R. V. L. Hartley in the *Bell System Tech. Journal*, July, 1928.

another way, means are required which will *pass freely* desired bands of frequencies, while *highly attenuating* or extinguishing neighboring undesired bands of frequencies. This is the essential function which the wave filter serves.

Equalizers

In any telephonic signal which is to be transmitted efficiently, proper audition requires that all component frequencies be treated alike, in so far as efficiency of transmission is concerned, in order that some frequencies may not be unduly emphasized to the detriment of others. This uniformity of efficiency of a band of frequencies is required, of course, primarily as a characteristic of the over-all system traversed by the signal. Some parts of a transmission system are inherently not capable of closely uniform transmission. For example, unloaded lines have an attenuation which rises gradually with frequency. The equalizer cannot restore the loss of effectiveness which occurs to some frequency components due to such distortion. Amplification of power requires such generative devices as vacuum tubes. What the equalizer can do is to attenuate efficiently transmitted frequencies in such a manner and to such an extent that all desired frequencies suffer or prosper in transmission alike.

Telephone Transformers

Efficiency of transmission in telephone circuits is governed largely by "matching of impedances" at junction points in a circuit. This is the chief purpose of telephone transformers. Because of the relatively high frequencies employed in telephone work and because a rather wide band of frequencies needs to be transmitted, inherent internal impedances, such as those of winding capacities, become very important and require that the telephone transformer be considered primarily as a network. In the case of transformers working into the very high input impedances of vacuum tubes or providing band transmission at high frequencies, we may say that the frequency range of transmission and the transformation ratio of telephone transformers is as completely dependent upon the magnitude of inductance and capacity elements as are the characteristics of wave filters.

Line Balancing Networks

The two-way repeater circuit has essentially the form of an a-c. bridge in which a balanced condition depends upon both the similarity of certain transformer (hybrid coil) windings and the equality of impedance of the two halves of the repeater output circuit. In the case of the 21-type (two-way, one-amplifier) repeater, the two halves are the telephone lines joined by the repeater. In the case of the more stable 22-type (two-way, two-amplifier) repeater, an output circuit exists at each end of the repeater and each telephone line is matched in impedance against a "dummy" line, or balancing network. The function of this network is solely to present the same impedance to the repeater over a range of frequencies as is presented by the line; *i. e.*, to simulate the impedance of the line. No *through* transmission is required of it. The design of such networks involves a choice of configurations of resistances, capacities, and inductances which bear a close physical relationship to such impedance elements of the line as dominate its total impedance, and a determination of impedance values of the network elements in accordance with network theory.

Artificial Lines

The function of artificial lines is to exhibit some transmission property, or properties, of a real line, at one frequency or over a range of frequencies, so that there may be compactly constructed a network which will serve for certain purposes involving wave propagation, in place of a real continuous line. The artificial line is generally a network of lumped, discrete impedance elements, whose constants are computed from network theory. One of the most common forms of artificial line is the variable *attenuator*, which is used as a basis of comparison in attenuation and transmission loss measurements. It is usually constructed of resistances so that over a wide range of frequencies it displays uniform attenuation. Other forms of artificial line, however, over a range of frequencies display the varying attenuation (and perhaps phase) properties of real lines and circuits and involve properly disposed inductance, capacity, and resistance units. In contrast to the equalizer, they simulate, rather than compensate for, frequency-transmission characteristics.

III. Secondary Functions of Transmission Networks

The functions of transmission networks outlined in Section 2 show the ordinary reasons for their employment in communication systems. When so employed, however, since they must fit into the transmission scheme of systems and work harmoniously with other apparatus, they may be faced with numerous additional requirements. Occasionally, the latter duties may even provide the more difficult design requirements. The more important of these possible secondary requirements follow:

Efficient Transmission

This requirement applies particularly to transformers, wave filters, and equalizers. Each of these types of apparatus could fulfill its principal duties while consuming an *undue portion* of the strength of signals entrusted to it. Under some conditions, amplification of signals by the use of vacuum tubes could offset this consumption from a transmission standpoint at an economic sacrifice, and the problem would then be one of economic balance; but in other cases the amplification would be objectionable because accompanied by such factors as amplification of noise, impoverishment of circuit balance, and loss of circuit flexibility. Efficient transmission is secured by proportioning materials so as to limit dissipation of energy.

Low Distortion

It is not possible, of course, to secure entirely uniform transmission of all signal frequencies; and, indeed, refinements of transmission in this direction beyond a certain point have economic limits. The quality of signals is impaired, however, to the extent that distortion exists. When distortion is excessive, equalizers often provide a desirable way of reducing it, but do so at a sacrifice in over-all circuit efficiency.

Impedance Balance

There is a number of kinds of impedance balance commonly found in communication circuits. All of them are akin to balances in a-c. bridge circuits. They need to be maintained over bands of frequencies. Balancing arrangements offer a kind of selectivity which differs from filter selectivity in that in general it keeps apart throughout systems two trains of waves arising from different sources and drawn off to different destinations, instead of separating on a basis of frequency difference waves which have mingled in a common circuit. An example is the balance necessary in a side-circuit, and therefore imposed on transformers or filters located in the latter, in order that currents traveling a superimposed phantom circuit may not interfere with side-circuit transmission. A second kind of balance is the repeater balance mentioned in Section 2, which may lead to requirements on, say, filters located in the output circuits. Here the separation is between incoming and outgoing speech signals using the same frequency range. In other cases, circuit balance is relied upon to prevent interference currents set up between circuit wires and ground from entering the circuit of the former. To obtain a high degree of balance, apparatus located in a balanced circuit must be quite symmetrical in its circuit impedances with respect to the associated circuit from which it is protected by balancing.

Stoppage of Longitudinal Currents

Longitudinal currents are those which travel both sides of a circuit in the same direction as parallel paths and return by some other path, generally a ground circuit. They are objectionable because (1) they tend to enter the transmission circuit whose sides they travel,—in this case called a transverse circuit—through irregularities of balance in the latter, and to unite with transverse currents; and (2) in many cases they correspond to objectionable voltages of considerable strength. They may be eliminated in two ways; (1) by providing for them a short-circuit path to ground in the longitudinal circuit, and (2) by causing virtually an open-circuit gap to occur in the longitudinal circuit, each of the methods being so employed as not to affect transmission in the transverse circuit. Transformers are required by either method.

Transmission in Closely Associated Circuits

When the same wires are used to provide both side circuit and phantom circuit transmission, it is a requirement of apparatus (such as transformers and filters) inserted in side circuits that they shall not impair transmission in the phantom circuit, and vice-versa. This means that apparatus in one circuit must not insert impedance in another circuit and requires close coupling between those impedance elements of networks which are located in series with the line wires.

Stability of Characteristics with Current Variations

If the inductances, resistances, or capacities of a network are subject to variations in value with varying current strength,—as for example, is the case with the inductance and resistance of coils using unstable core materials,—two detrimental results are possible. First the frequency characteristics of the network will be distorted as the current varies from its mean value. Second, a kind of modulation will occur, resulting in the generation of new frequencies whose presence will interfere with interpretation of signal waves traversing the network. Stability of characteristics is obviously to be secured by the use of materials whose permeability, resistance, and dielectric constant do not vary with current strength.

Low External Coupling

It is desirable that electrostatic and electromagnetic coupling between a network and parts of its own or other circuits be kept low; that is, that the network be self-contained electrically and receive and supply energy only through its normal input and output terminals. When coupling exists to some other circuit, (1) energy introduced from the latter circuit may interfere with signals or (2) energy derived from the network may cause interference in the circuit to which it is coupled. When coupling exists to other parts of the circuit in which the network is located, (1) impedance balances may be upset, (2) large attenuations, as of a filter, may be nullified by bypass circuits, and (3) circulating currents of considerable strength may be set up when vacuum tubes are involved in the circuit. Electrostatic and electromagnetic shielding permits control of external coupling.

Low Reflection Coefficient

Where networks connect directly or through other transmitting networks to a line, it is desirable that the impedance offered by the network-to-line currents be such that wave reflections are not set up in the line by impedance mismatches at its ends. Reflections result not only in undesirable transient waves in the circuit in which they originate, but cause interference into other circuits and complicate line transposition problems. Hence an impedance characteristic is usually prescribed for a network.

Parallel or Series Operation

It is a requirement, particularly of groups of wave filters selecting signals for a number of communication channels, that the impedance of each in the transmitting ranges of the others be such as not to interfere with the

operation of the latter. In the case of filters operated in parallel, this means a high shunting impedance; in the case of filters operated in series, a low series impedance. It is possible to meet this requirement since, in general, numerous configurations of filter elements which will meet given transmission requirements but allow wide latitude of choice of impedance characteristics, can be arranged.

A number of considerations should be noted with respect to the above requirements. First, in any given circuit conditions, the requirements can be expressed in numerical measure so that networks can be designed to meet them quantitatively, and measured accordingly when constructed. Secondly, the various requirements which might be imposed on a network by circuit conditions tend, for the most part, to be conflicting, since they restrict choices of design, and must be evaluated and balanced from an economic standpoint. Finally, the ability of a network to meet the above requirements is subject to physical limitations which will be discussed in Section IV.

IV. Engineering Limitations on Network Design and Construction

To work out theoretically a network of inductances, capacitances, and resistances which will offer certain desirable transmission characteristics over a frequency range, is a matter of following certain theoretical design methods. To build actual networks which will possess and retain these characteristics involves a large number of factors which come into play and which must be balanced against one another.

Accordingly, it is necessary to point out the principal directions in which limitations are to be encountered, for the value of network design methods is limited exactly by the degree to which networks may be physically constructed so as to give desired characteristics.

Between the indicated theoretical performance of a network and its actual performance there enter in generally four types of discrepancies. They are concerned with the following four questions: (1) How accurately does the indicated theoretical performance correspond to the exact theoretical network chosen? (2) How nearly is the actual form or configuration of the network what it is theoretically supposed to be? (3) How accurately is the network constructed? (4) How stable are the characteristics of the network during operation?

There are two sources of error which affect the theoretical exactness of the computed performance of a network; both have to do with the approximations which are necessary when mechanical aids are used in computation. One lies in computations of the network constants (L's, C's, and R's) from chosen significant frequencies, impedances, or other design bases, and the other, in determinations of the characteristics themselves either from the network constants or from the bases referred to. Ordinarily, when reasonable care is used, discrepancies of either kind are not large enough to be important except in the case of apparatus which needs to be made very accurately.

The form or configuration of a network introduces four important factors leading to discrepancies; *viz.*, (1) interactions between network elements, (2) distributed impedance effects in the elements themselves, (3) admittances from elements to ground, and (4) effects of the wiring system. These are important factors which generally must be given careful consideration.

For a given design, accuracy of network construction is dependent, primarily on (1) the accuracy of electrical measuring circuits used in conjunction therewith, (2) the fidelity of test conditions, and (3) the care and skill exercised in making adjustments. This assumes that the design is such mechanically as to permit close adjustments to be made.

Stability of network characteristics under operating conditions is largely dependent on the materials employed in construction. Suitable materials are usually limited in number either by economic considerations or by the limitations of engineering knowledge. The chief sources of instability of characteristics are: changes with current variations (either temporary or permanent), changes due to temperature and humidity fluctuations, and a group of changes called "aging" which have to do with releases of stresses and fatigue of materials.

ENGINEERS REVIEW PROGRESS

The summer convention of the American Institute of Electrical Engineers, held at Swampscott, Mass., last week, was notable for a group of technical committee reports that surveyed the several fields of engineering and for many papers that presented new developments in the art. It was made evident that the engineers are very busy these days and that the Institute is serving as a splendid rallying place for their social and technical activities.

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The Institute is a needed agency in holding together the professional electrical engineers. It gives opportunity for the specialists to meet as a group to discuss their problems, and at the same time it serves as a unifying agency to weld together all electrical engineers into a professional entity. Moreover, it develops a sense of civic responsibilities and of the higher values in life so well outlined by President Schuchardt in his address. Any one who attended the Swampscott meeting came away with renewed loyalty and enthusiasm for the Institute and with the knowledge that the electrical engineers are continuing the work that is fundamental to the growth of the industry.—*Electrical World.*

Abridgment of

The Electrification of the Mexican Railway

BY J. B. COX[1]

Associate, A. I. E. E.

Synopsis.—The Mexican Railway Company, Ltd., locally known as Ferrocarril Mexicano, was the first railway built in Mexico, having been opened to traffic January 1, 1873. The main line runs between Mexico City and Vera Cruz and is 264 mi. in length. There are six branch lines which increase the route miles to a total of 482. The most difficult portion of the line consists of 19 mi. of 4.7 per cent grade between Encinar and Boca del Monte where the table-land is reached.

In 1921, when the road was returned to its owners, following five years of government operation, the property was found to be in an unsatisfactory condition, with operating expenses more than doubled, thereby increasing the operating ratio from 0.51 in 1914 to 0.79 in 1920. Higher wages and new working agreements were largely responsible and continued to become more difficult. The mountain division had about reached its maximum capacity with the existing equipment, making it necessary to consider improvements.

A study of the operating costs of this section was made in 1921 from which it was apparent that the electrification of that section would readily relieve the congestion and make it possible to more than double the capacity of the line, and at the same time accomplish a yearly saving of $523,000 in operating expense. The electrification was estimated to cost $2,420,000, thus indicating a return of 21 per cent on the gross investment including electric locomotives, in addition to the increased capacity and many other advantages.

Construction work was started in January 1923 and electrical operation between Orizaba and Esperanza was complete in January 1925. The total cost for the 29 mi. section was $2,427,480.00. Internal disturbances delayed the work several months and reduced the traffic greatly. In March and April 1928 the traffic becomes comparable with that of September and October 1921, for which period the actual traffic records and operating costs for steam operation had been used as a basis for comparison with the estimated cost of an equal traffic with electrical operation.

A comparison of actual operating costs of items affected by electrification for the two periods showed that 10 electric locomotives had hauled 36 per cent greater tonnage in 40 per cent less train hours than had 25 steam locomotives and at 50 per cent of the cost for items affected. When the figures were properly adjusted to compensate for increased tonnage and higher wages, the saving indicated was at the rate of $663,348 per year, a return of 26 per cent on the total cost of the electrification.

In the meantime the general results had been so satisfactory that the electrification was extended 35 mi. south to Paso del Macho, making a total of 64 mi. at a cost of $3,606,937.00.

THE electrification of the Mexican Railway (Ferrocacrril Mexicano) is of special interest as being the first undertaking of this nature carried out in old Mexico. The initial study of the problems involved was made in 1921, and in 1922 a contract was signed for the construction work and for the electrical equipment. In 1925 the work was completed and electrical operation started.

The operation has been so conspicuously successful that it would now seem to be of general interest to describe many of the details of construction and to give such operating data as are available.

The main line of the Mexican Railway extends from Mexico City to the Gulf Coast at Vera Cruz and is 264 mi. in length. There are six branch lines, making the total route miles 482.

From Mexico to Esperanza the line follows the general contour of the plateau, resulting in frequent reversal of gradients, but none exceeding 1.5 per cent. The elevation at the terminus in Mexico City is 7346 ft. The highest point on the line is near Acocotla, 95 mi. from Mexico, at an elevation of 8320 ft., a rise of about 1000 ft. From this point to Esperanza, a distance of 58 mi., the drop is 240 ft. with the surface undulating as before.

At Boca del Monte (The Mouth of the Mountain), 3.8 mi. west of Esperanza, the plateau ends suddenly, and the descent for the following 19.0 mi. to Encinar is very rapid.

At Santa Rosa the line enters the Valley of the Rio Blanca and the grade becomes normal on to Orizaba.

From Orizaba to Paso del Macho the drop is considerable though much less rapid than that just described. In the 35 mi. there is a descent of 2466 ft. There are some comparatively long sections of tangent track, and the curves, except in the loop on the Metlac Bridge, are not unusually numerous or seriously sharp.

The original charter for the road was granted in 1855 and it was opened for through traffic January 1, 1873, eighteen years later.

The history of its promotion, construction, and operation was in close synchronism with that of the country. The road had become prosperous during the comparatively settled conditions under the rule of Diaz, but the revolution of 1910 established a new government which, in November 1914, took the road from its owners and operated it until August 1916, when it was returned to the owners. It was again seized in April 1917 and held until June 1920, making more than five years of government operation.

When returned, the property was in very poor condition, much of the equipment being inoperative, and with no materials for repairs. Operating expenses had also been abnormally affected during the interval by substantial increase in wages, as well as by unusually expensive working agreements insisted on by newly formed labor organizations, all of which were becoming increasingly burdensome.

1. General Electric Co., Schenectady, N. Y.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

The semi-annual reports of the Mexican Railway for the six months ending December 31, 1920, the first period of operation after the return of the property by the Government, compared with a similar period of 1913, the last six months of operation by the owners prior to Government operation for which the records were available, indicated that the operating costs had more than doubled during the interval, thereby increasing the operating ratio from 0.51 in 1914 to 0.79 in 1920.

In the fall of 1921 the business on the railway had grown so that it became very difficult to get the traffic over the mountain division from Orizaba to Esperanza, which had always been the proverbial bottle neck. On October 25 a total of 14 trains, two of which were passenger, (an aggregate of 4648 tons), was taken up the mountain, establishing a record for the division and indicating that the economic capacity of the single track line with existing type of motive power had been reached and that improvements of some kind were necessary.

In November 1921 a study of the mountain division was begun for the purpose of determining the results that might be expected from the electrification of this congested district. About two months were spent in looking over the line and equipment, studying the conditions and securing operating data and costs. An equal time was required to analyze these data, estimate the cost of electrification and the savings in operating expenses that would result, and to prepare a report which was submitted in April 1922.

The unsettled conditions that had existed in the country for the preceding ten years and the taking over of the railroad by the Government between 1914 and 1920 rendered the records for any of this entire period unsuitable for forming a basis for the usual method of estimating the traffic that might reasonably be expected over the line for the following years.

The management of the railway suggested that the months of September and October 1921 should be taken as a basis for the study since the traffic conditions and operating costs during that period were more representative of anticipated future conditions than any other period for which records were available.

The mountain district constituting the line between Orizaba and Esperanza, a distance of 29.5 mi., was then operated as a separate district, and accurate operating expenses and statistics for steam operation were readily available for comparison with corresponding estimated costs of electrical operation.

The line between Orizaba and Paso del Macho was also included in the original study, but since this was operated with the remainder of the line on into Vera Cruz and the result of electrification could not be so definitely determined until an exact schedule of operation had been decided upon, only an approximate estimate was made for this section.

Of the 29.5 mi. between Orizaba and Esperanza, the 19 mi. between Encinar and Boca del Monte which had been given careful consideration in the original survey again became the determining factor relative to motive power. The actual rise in the 19 mi. is approximately 3500 ft. equal to an uncompensated grade of 3.5 per cent. With the exception of the first 2.5 mi. of this heavy grade just out of Encinar there is practically no tangent track, but continuously reversing curves many of which are on a radius of 351 ft., equivalent to 16.5 deg.

In locating the line it was apparently intended to keep the uncompensated grade at a maximum not to exceed 4 per cent, and the maximum curve at 16.5 deg.

A check on the most difficult point on the line revealed that on short sections of the line 500 ft. in length the compensated grade was 5.24 per cent. The average grade for 1¼ mi. at this point was 4.7 per cent which was therefore considered the ruling grade for the division in preparing the specifications for electric locomotives.

The average weight of the passenger trains was about 235 tons but they varied between 165 and 350 tons.

The steam locomotives that were generally used for handling both freight and passenger trains on this division consisted of 32 four-cylinder Fairlie engines, of English build. These engines were designed especially for mountain service having pack-saddle type tanks for fuel oil and water over a double-ended boiler which was mounted on two three-axle swivel trucks, all the weight being on the drivers. The engines had the appearance of two three-axle switching locomotives coupled with cab ends together.

The firebox was in the middle of the engines and contained two oil burners, the cab being over this central portion and the engineer located on one side of the boiler with the fireman on the opposite side. The engines ran equally well in either direction, and having a comparatively short rigid wheel base with all weight on the drivers, at once deprived the electric locomotive of three of its usually boasted advantages.

The 32 engines were all of the same general type but of variable ages and weights ranging from 84 tons to 152 tons. Practically all freight trains and most of the passenger trains required two engines. In the case of the passenger trains, both Fairlie engines were placed at the head of the train with a box-car between; and with the freight trains, an engine was placed at each end. The average weight of the trains, up grade, was 317 metric tons or 350 U. S. tons. The down grade tons were considerably less as almost two-thirds of the traffic was northbound.

The operating data and actual costs of the steam operation for the months of September and October 1921 were taken as a basis for estimating the saving that might be expected to result from the electrification of the Orizaba–Esperanza district. Only the items of operating costs which would be most vitally affected were considered. The estimate as submitted in the report follows:

	Steam	Electric	Saving	Ratio steam to electric
Wages of enginemen	$108,892	$ 31,354	$76,538	3.44
Wages of trainmen	85,290	23,191	62,099	3.68
Fuel and power	221,790	150,000	71,790	1.48
Repairs to locomotives	355,248	51,111	304,157	6.95
Enginehouse expense	20,946	5,841	15,105	3.57
Lubricants	16,656	2,921	13,735	5.70
Substation oper. and maint.	..	11,750	..	..
Maint. distributing system	..	9,625	..	..
Total	$808,822	$285,793	$523,029	2.82

The estimated cost of the electrification as submitted was:

10—150-ton electric locomotive units	$1,420,000
1—6000-kw. substation	350,000
30—Route miles distributing system	430,000
Engineering and contingencies	220,000
Total gross capital investment	$2,420,000

The report accordingly indicated a probable saving of $523,029.00 per year by the expenditure of approximately $2,420,000; or a return of slightly more than 21 per cent on the gross investment which included electric locomotives.

A similar study of the line between Orizaba and Paso del Macho was made at the same time, but as the savings that seemed probable were sufficient for a return only about half that of the Orizaba-Esperanza district, the report recommended that only the latter be undertaken in the beginning.

After a very careful examination of the report by the Operating Department of the railway, it was approved and recommended to the Board of Directors.

In October 1922 a contract was made for the required equipment and materials including the general supervision of the installation. Actual work on the ground was begun in January 1923 and the work was completed and all trains being hauled electrically by January 1925.

Distribution System

The simple catenary system with a double 4/0 trolley over the main line and a single 4/0 trolley over passing tracks and yards, similar in general to that used on the Chicago, Milwaukee, St. Paul & Pacific Railway, was adopted.

Of a total of 1920 poles required for the supporting structure, 405 were concrete and 1515 were made from old 82-lb. rails which had been replaced and temporarily abandoned. The cost per pole was $45.52 for concrete and $34.00 for the rail.

Bracket construction was used generally. Two 500,000-cir. mil copper positive feeder cables and one 4/0 negative feeder cable were used over the greater distance of the line, and a single 250,000-cir. mil electrically-welded bond was installed at each rail joint. The cost of the distribution system inclusive of poles and fixtures for the 29.50 mi. was $462,011.00 or $15,661.00 per route mile including an 8-track yard one-half mile in length at Orizaba.

In 1926 the trolley line was extended 16 mi. eastward to Cordoba at a cost of $233,556 or $14,597 per route mile including an 8-track yard at Cordoba similar to that at Orizaba.

In May 1928 the distribution system was completed to Paso del Macho, 18.5 mi. south of Cordoba, with only a single 500,000-cir. mil copper positive feeder to Potrero and a 4/0 negative feeder throughout at a cost of $230,676.00, or $14,090.00 per mile. The total cost for the 64 route miles of distribution was $926,243.00, or an average of $14,472.00 per route mile.

Substation

One substation located at Maltrata, practically in the center of the distribution system,—10.2 mi. by feeder

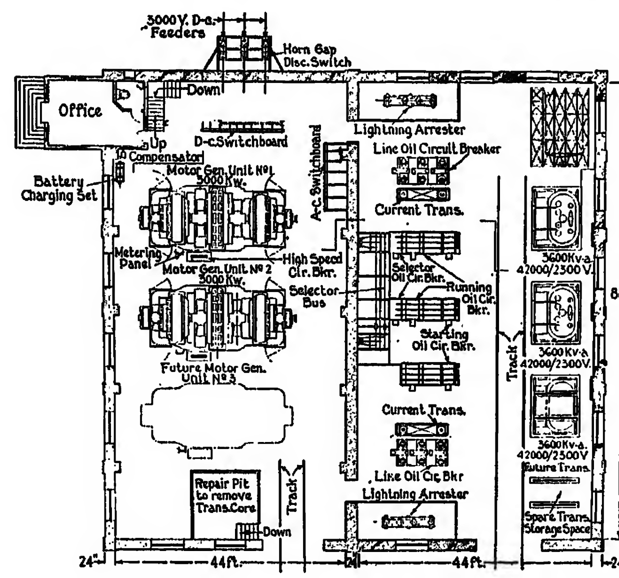


FIG. 8—PLAN OF MALTRATA SUBSTATION SHOWING LOCATION OF APPARATUS

from each end, and the Bota loop which is 7.5 mi. around, located in between—was sufficient for the service.

Fig. 8 shows a plan of this substation and Fig. 9 the interior of the generator room.

Power is purchased from the Puebla Tramway Light & Power Co. at 42,000 volts, three-phase, 60 cycles. The equipment of the substation consists of two three-unit, 3000-volt motor-generator sets, with transformers and switching gear, all of which are standard apparatus of the same general design as used on the Chicago, Milwaukee, St. Paul & Pacific, Spanish Northern and Paulista Railroads.

Building room and completed foundations are provided for a third similar unit when desired.

The extension to Paso del Macho required a second substation located at Potrero, 39 mi. from Maltrata. This is practically a duplicate of the Maltrata station except that the units are of 1500-kw. capacity, the grades being much less on this end of the electrified

section. The total cost of the Maltrata substation inclusive of buildings was $452,725 or $75.50 per kw. The cost of the Potrero station was $234,194, equal to $78.00 per kw. or an average for the two of $10,733.00 per route mile of electrification.

Locomotives

Ten 150-ton electric locomotive units, class B+B+B, equipped with six twin-geared motors, mounted on three articulated trucks, were supplied for the initial electrification. Each unit is capable of exerting a continuous tractive effort of 50,000 lb. at 18 mi. per hour with 2700 volts at the locomotive, and has three speed combinations which provide continuous running points for 6, 12, or 18, m. p. h. at full tractive effort; and two shunting points provide correspondingly higher speeds on each of these combinations with lighter loads up to 40 m. p. h. These locomotives are provided with regenerative braking features.

Two additional duplicate locomotives were supplied

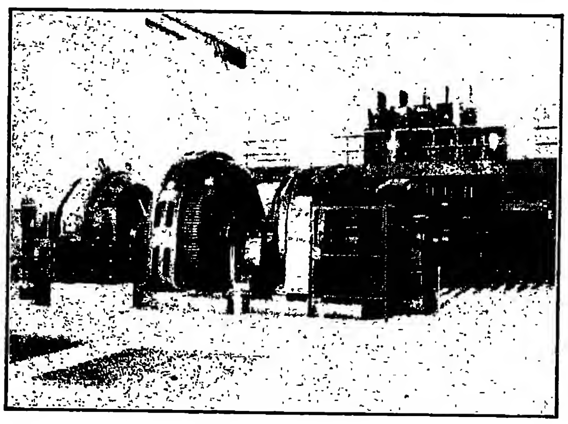


Fig. 9—Interior of Maltrata Substation Showing two 3000-Kw., 3000-Volt Motor-Generator Sets and High-Speed Circuit Breakers

this year for the extension to Paso del Macho, making a total of 12 units for the 64 mi. of electrification. All locomotives are suitable for both freight and passenger service.

Transmission Line

A 42,000-volt transmission line, consisting of six steel centered 1/0 aluminum cable supported on "A" frame steel poles with anchor towers about each five pole, was built to bring the power from the Tuxpango Power House to Maltrata, a distance of 17 mi. The cost of this line was $187,242 or about $11,000.00 per mile. A similar line of about equal length, except that only three conductors will be installed for the present, is under construction to Potrero.

Electrical Operation

The Orizaba-Esperanza district has been in full operation electrically since January 1925, thus making the records available for four years. The operation has been quite successful, as may be judged from the total complaint account which was about $3,000.00, and by the maintenance and operating costs given herewith.

The rebellion which occurred unexpectedly in December 1923 not only increased the cost of the construction by completely stopping the work for four months just when fully organized, but was also responsible for a general recession in business which reduced the traffic over the electrified line to about 65 per cent of that for the period used in the estimate.

Early in 1928 traffic increased to a point some in excess of that during September and October 1921, thus affording an opportunity to check the estimates which had been made in the report leading to the electrification. Operating records practically identical with those for September and October, during steam operation, were obtained for the months of March and April 1928 with complete electrical operation. The comparison for the two periods showed that after proper adjustments had been made for increased prices, for fuel and wages and the excess tonnage, the operating costs for March and April with, electrical operation, were at the rate of $404,652.00 per year as against $1,068,000.00 per year with steam operation, thus indicating a saving of $663,348.00 per year or 62 per cent in favor of electrical operation.

The adjusted costs of steam operation and the actual corresponding costs of electrical operation placed on a yearly rate for direct comparison and for checking the estimate were as follows:

			Saving	
	Steam	Electric	Indicated	Estimated
Enginemen	$185,946	$87,390	$98,556	$76,538
Trainmen	130,332	64,326	66,006	62,099
Fuel or power	300,834	186,840	113,994	71,790
Repairs to locomotives	408,354	35,814	372,540	304,137
Enginehouse exp	23,388	11,670	11,718	15,105
Lubricants	19,146	552	18,594	13,735
Substa. oper. maint	..	12,924	..	..
Trolley oper. maint	..	5,136	..	..
Total	$1,068,000	$404,652	$663,348	$523,029

The indicated saving of $663,348.00 per year in favor of electrical operation is 27 per cent greater than the estimated saving of $523,029.00, but this is largely accounted for by the 36 per cent increased tonnage actually handled above that on which the estimate was based.

The savings indicated for the items listed represent 26 per cent earnings on the gross cost of the electrification of the 29.5 route miles of the district electrified, which alone should be considered a very satisfactory investment; but with the addition of the many other advantages resulting,—such as increased capacity of the line, reduction in running time, wear on wheels and brake shoes,—with consequent reduction of accidents from broken wheels due to overheating while braking, all of which, if fully valued would add many hundreds of dollars to the credit of electrical operation; those items ordinarily being too difficult to accurately segregate into definite amounts.

The earning on investment as shown is on the gross investment including the cost of electric locomotives, whereas steam locomotives to do an equal service on this section of steep grade would have cost approximately as much as the electric locomotives. Therefore, the cost of electrification should be entitled to a credit amounting to the cost of the locomotives, which in this case would reduce the cost of the electrification about 46 per cent, and thus make the earnings on the net investment for the electrification about 47 per cent.

The gross cost of the 64 route miles now electrified, including transmission line now under construction and two duplicate locomotives recently delivered, was approximately $3,607,000.00 or $56,358.00 per route mile electrified. The original estimate was $4,032,500.00, but experience from the two years' operation of the original district made it evident that the traffic could be handled safely with 20 per cent less electric locomotives than had been thought necessary at the time the estimate was made.

Speed Indicator and Frequency Meter

BY E. H. GREIBACH[1]

Non-Member

***Synopsis.**—The design of a simple mechanical speed indicator, consisting of a rotating cup and a ball placed inside of the cup, is described and discussed. This speed indicator can be built to give precise indication through a range of ± 2 per cent of a given speed. The order of precision in reading is about 1/10 of 1 per cent. When driven positively by a synchronous motor, it can be used as an accurate frequency meter.*

* * * * *

THE fact that centrifugal forces are proportional to the speed of rotation has been utilized in the design of many mechanical speed indicators. These indicators consist either of rotating masses whose centrifugal forces are balanced by means of springs or weights, or they are rotating containers in which liquids are made to assume various shapes. In the first case, a delicate system is required to indicate the position of the masses, while in the second case, a complicated shape of the container is required in order to get a correct and easily observable indication of the speed of rotation.

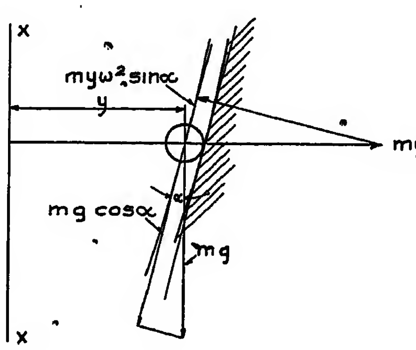


Fig. 1

Although based on the same law of proportionality between speed and centrifugal force, the apparatus described in this paper offers greater simplicity and ease of operation.

1. Research Department, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

A cup-shaped container, preferably transparent, rotates around a vertical axis. One or more balls of suitable material, such as steel, are placed inside the cup. These balls are subject to the influence of centrifugal forces as the cup rotates. (Fig. 1)

The centrifugal force acting on each ball has a component in a direction tangential to the generatrix

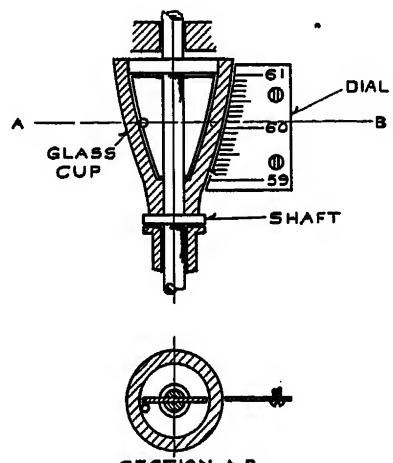


Fig. 2

of the inside surface of the cup. (Fig. 2) This component causes the ball to climb along the inside wall until it is counterbalanced by the component of weight acting in the opposite direction; or, in other words, the ball is in equilibrium on a point of the generatrix when the centrifugal force and gravity give a resultant which is perpendicular to the tangent. It is evident that the slope of the tangent is a function of the radius and the

angular velocity of the cup. Therefore, when a cup is made whose slope and radius vary in a proper manner, each point on the generatrix corresponds to a definite velocity for which the ball is at rest. By providing a stationary scale, properly graduated, the speed corresponding to each position of the ball can be read.

The inside surface of the cup can easily be calculated to give any required scale distribution. For most of the applications a uniform scale is desirable. The calculation carried out for a speed indicator having a uniform scale distribution shows that it is very easy to build cups for a narrow scale range; *i. e.*, cups which would indicate the speeds varying through a range of $\pm$ 2 per cent (or less) of a given speed. In the design of the cups, due consideration must be given to the rotatory velocity of the cup. It can be shown that the curvature of the generatrix of the cup surface varies inversely as n_0. Since a greater curvature is desirable in the design of the glass cup, it is advisable to reduce the cup velocity by means of gears when designing indicators for high velocities. The indications of the cup are independent of the specific mass of the material from which the balls are made; however, the diameter of the balls has a certain influence, an increase in the diameter of the ball will shift the scale into a slightly higher range. This influence of the diameter of the balls can be used while calibrating cups in order to correct for some deviation from the exact dimensions.

The cup must be set in vertical position to insure maximum accuracy. It should be pointed out, however, that precision in setting the cup, although desirable, is not essential for ordinary commercial purposes. If the cup is steep, this is true because for small angles of deviation from the vertical, the variation of the component of gravity parallel to the generatrix is negligible.

A desirable feature of the apparatus is its property of indicating only the average when the speed undergoes rapid fluctuations. This characteristic is easily explained by remembering that the ball, however small, possesses a certain amount of inertia and that the effect of friction is negligible against the effect of inertia. Furthermore, it was found by experiment that on account of the friction being very small, the indicator acts sluggishly; *i. e.*, the ball does not readily follow variations in the speed of the cup. Therefore it is necessary to provide a means of accelerating the ball. A convenient means is to use a transparent vertical plate inside of the cup, fastened to the shaft and extending, radially, close to the inner surface of the cup, as shown in Fig. 1.[2]

The indicator does not contain any parts that are subject to rapid wear or deterioration. It will maintain its calibration therefore, over an indefinite period of time.

The logical application for this instrument is for accurate indication of small variations in speed. By properly designing the cup, very positive indications of plus or minus 2 per cent of a given speed can easily be obtained. Of course the apparatus can be made to give indications of speeds varying over a much wider range if desired.

When driven positively by a small synchronous motor, this instrument can be used as a precise frequency meter, having a full scale range corresponding to two cycles or less when based on 60 cycles. As the cups can be made quite long, these frequency meters can be used to indicate frequency variations as low as one-tenth of one cycle.

2. The writer is indebted to C. R. Hanna for the suggestion of this construction of the accelerating plate.

ELECTRIC POWER IN THE SOUTH

That the electrical development of the southern states has been the most important factor in the economic renaissance of this section is generally recognized; but the fact that in recent years the South has been forging ahead electrically at a far more rapid rate than has the country as a whole may not be generally known.

The actual figures are rather amazing. They show that during the five-year period from 1922 through 1927 the increase in generator capacity in the 15 southern states was 122 per cent as compared with 80 per cent for the entire country; while the increase in kw-hr. output during the same period was 134 per cent in the South as compared with 85 per cent for the country as a whole.

During 1928 the increase in output for the entire country was nearly 10 per cent; while in the southern states alone, the increase was more than 15 per cent. The figures of the U. S. Geological Survey for the first two months of 1929, as compared with the same period of 1928, show that this ratio is still being maintained.

This rapid rate of increase brought the South's proportion of the total output of the entire country from approximately 16½ per cent in 1922 to more than 20 per cent last year. Production in the South last year was nearly eighteen billion kw-hr. as compared with less than eight billion in 1922.

There has been an amazing increase in efficiency of fuel plants in recent years. In 1919 coal consumption averaged 3.2 lb. per kw-hr., while in 1928 this had been reduced to 1.76 lb., or a reduction of nearly 50 per cent. But despite this increased efficiency of fuel plants, which has been widely proclaimed, the output by water power has increased more rapidly than the output by fuel power during the last four years. Last year nearly 40 per cent of the total output of the country was generated by water power, while in the southern states the proportion was nearly 50 per cent.—*Electrical South.*

TRANSATLANTIC TELEPHONE CABLE

Last year the American Telephone and Telegraph Company announced that the Bell Telephone Laboratories had perfected a deep sea telephone cable suitable for transatlantic operation. Work is now going forward actively on the development of a cable system of this type for connection between London and New York City and it is possible that this circuit will go in service as early as 1932. While the new cable will yield only a single telephone circuit, this will be one of maximum reliability, free from the variations characteristic of radio circuits. It is not the idea that the cable will replace radio circuits but it will add considerably to the reliability of New York-London service as well as adding to the total message capacity.

The route of the cable is not settled in detail, but it is probable that the main transatlantic link will extend directly from Newfoundland to Ireland, a cable length of approximately 1800 nautical miles. From Newfoundland it is expected that the circuit will be carried through several sections of submarine cable to Nova Scotia; thence by land circuits through Nova Scotia, New Brunswick, and the New England states to New York City, where it will terminate. From Ireland the circuit will probably be carried through submarine cable to Scotland and thence by land cable to London, which will be the other terminal.

The new cable will be of the continuously loaded type. For the loading material, it is planned to use one of a new series of alloys which are designated as "perminvars." These are composed of nickel, cobalt, and iron, to which may be added small amounts of non-magnetic metals such as molybdenum. They are characterized by high resistivity and by having a constant permeability over a wide range of magnetizing force.

The conductor will be insulated with a new material "paragutta." Submarine cables in the past have been insulated with gutta-percha or closely related materials, and in a few cases with rubber compounds. Paragutta makes use of similar raw materials, but so combined and treated as to give superior electrical properties with mechanical properties similar to gutta-percha.

A remarkable feature of the cable is the high attenuation which it is proposed to use. It is possible that successful operation can be obtained with an attenuation of approximately 150 db. for the high frequencies of the voice range. This is a much greater attenuation than that at which telegraph cables are operated. Such a high attenuation depends on two features of the cable; the characteristics of perminvar are such that a relatively high sending level can be used, and by means of special construction, the cable will be shielded against interference so that a very low receiving level can be employed.

To make two-way operation possible, voice-operated switching mechanisms will be required at the two terminals. These devices will permit the circuit to be operated only in one direction at a given time, this direction of transmission, however, being automatically controlled by the speech waves of the two talkers so that conversations may be carried on in a perfectly natural manner.

IRON AND STEEL PRODUCTION

Annual Report of Committee on Applications to Iron and Steel Production*

To the Board of Directors:

Because of the magnitude of the projects and the rapid development that is taking place in certain phases of the iron and steel industry, especially in regard to application of electric power an annual report of application of electric power, to the iron and steel industry must necessarily be a continued story from year to year. These developments are keeping pace with the investigation of the metallurgist, which investigations have resulted in new processes for shaping steel.

While during the past year, there have been no new steel plants built, many plants have added to their equipment. During the year of 1928, the steel industry purchased in main drive motors a total exceeding 200,000 hp., the units ranging from 300 to 7000 hp.

It is interesting to note that of this total, approximately 80 per cent are d-c. machines. This is largely a result of the installation of several new continuous mills with individual motor drive for each stand of rolls.

Synchronous motors for driving constant speed mills are increasing in number every year, and during the past year, synchronous motors have been supplied ranging in size from 400 to 5000 hp.

A mill drive of unusual interest which is now being installed is that for the 36-in. reversing Universal slabbing mill at the Steubenville, Ohio plant of the Wheeling Steel Corporation. This is the first instance in this country in which separate reversing motors are used for driving the horizontal and vertical rolls of the mill. The motor which will drive the horizontal rolls is a single-armature d-c. machine rated 7000 hp. continuous, 50/100 rev. per min., 750 volts.

The number of continuous mills having stands individually driven by adjustable speed motors still grows. The largest drive for a mill of this type which has been purchased during the year is that for the 60-in. wide strip mill at the Wheeling Steel Corporation's Steubenville plant. The total continuous rating

*COMMITTEE ON APPLICATION TO IRON AND STEEL PRODUCTION:
M. M. Fowler, Chairman,

A. C. Bunker,	A. M. MacCutcheon,	G. E. Stoltz,
F. B. Crosby,	C. Needham,	Wilfred Sykes,
A. C. Cummins,	A. G. Pierce,	T. S. Towle,
Samuel L. Henderson,	F. O. Schnure,	J. D. Wright.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Printed complete herein.

of the motors on this mill is over 20,000 hp., and d-c. power will be furnished by three 4000-kw., motor-generator sets.

During 1928 the American Rolling Mill Company placed in service a new wide strip mill. This mill is laid out to produce strip material up to about 60 in. wide and is one of the largest strip mills yet installed. The total capacity of the 11 driving motors is 21,800 hp.

The manufacturers of wide strips continue to enlarge their manufacturing capacity and apparently the end of their research and development is not in sight. The success of wide strip rolling is in considerable measure due to the accuracy that can be secured through modern electric drives and control equipment using individual motor drive of stands.

Time limit control of acceleration has now been in use on mill auxiliary drive for three or four years and has proved extremely successful.

A mill type motor which completely meets the recent standardization rules of the Association of Iron and Steel Electrical Engineers in all respects as to rating, speed, and dimensions is now in successful operation in a large number of steel mills, one installation of almost 200 motors having been in use for a year and a half with no troubles.

As regards the construction and design of main roll motors, such machinery is now largely being fabricated from rolled steel products by means of arc welding. The magnet frames of practically all of the large d-c. machines are now constructed from rolled steel slabs with feet and lugs welded to them. The stator frames of synchronous and induction motors are fabricated from steel plates and bars welded together, and the rotors of some of the synchronous motors are also being fabricated from plates and slabs.

The use of these fabricated frames has reduced cost and reduced manufacturing time for large electric motors. It also improves commutation and other characteristics, and it has become a definite feature in the new era of steel mill electrification.

The statistics for 1928 show that there was a total of 188 cranes purchased in the iron and steel industry, all having electric drives.

In the field of yard transportation, the Diesel electric locomotive is proving extremely successful in reducing operating and maintenance cost.

During the current year, the Ward Leonard type of control has been successfully applied to blast furnace skip hoists at the Bethlehem Steel Company's Plant at Sparrows Point, and also at the Tennessee Coal and Iron Company in Alabama. Engineers may not generally appreciate the limitations of the hoist equipment of blast furnaces, particularly on those furnaces that have been greatly increased in size in the last few years and are equipped with hoists of the single bucket type. The Ward Leonard control installed at Sparrows Point has quite materially helped furnace filling conditions and made it possible to secure increased outputs on their furnaces.

The electrically operated mud gun is one of the most outstanding developments witnessed by the blast furnace industry in many years. Before describing the new gun and its operation, a brief consideration of the work previously involved in stopping an iron notch will perhaps aid the reader unfamiliar with blast furnace operation to grasp the significance of the new development.

Tapping holes in the early days of ironmaking were closed by ramming in balls of fire clay with what was known in blast furnace parlance as a stopping hook. The operation was performed by hand and required keeping the furnace off blast for a short period of time. As the size of the stacks was increased, higher blast pressures were used and higher production obtained. This increase in the quantity of molten metal in the hearth and the blast tested the skill of the furnace keeper in stopping back the notch so that the iron would not trickle through after the blast was applied.

The mud gun, which is operated by three mill type motors, enables the operator to stop back the notch without taking the furnace off the blast.

Public utilities are showing increased interest in the possibility of assuming steel mill loads and have entered a few plants supplying a part of their power requirements. Because of the economical use of what have heretofore been waste gases around a steel mill, competition between the public utility and the steel mill in the generation of power is of course very keen. Apparently the possibility of a public utility entering a steel mill depends not upon its ability to take over existing load under competitive conditions, but the possibility of assuming new loads brought about by increased manufacturing capacity of the steel plant. This phase of the public utility power outlet is comparatively new, but is assuming greater importance each year.

During the current year, the first steel mill interconnected transmission system was placed in service by the Carnegie Steel Company and the National Tube Company in the Pittsburgh District. This transmission system consists of a long span, double-circuit tower line, similar in design to recent public utility practise. It is operated at the present time at 44,000 volts. Five steel mill and coke plant power plants, having generating equipment aggregating 150,000 kv-a., are interconnected. The purpose of this interconnection is to transmit in the form of electric power, excess by-product fuel available at any plant to other plants where a shortage of such fuel may exist. It is an essential feature in the complete utilization of excess blast furnace gas, coke breeze, etc.

INSTITUTE AND RELATED ACTIVITIES

A Most Enjoyable Summer Convention

HELD AT SWAMPSCOTT

One of the most thoroughly enjoyed meetings of the Institute was held June 24-28, when over 1000 members and guests attended the Summer Convention at the New Ocean House, Swampscott, Mass. A fine selection of technical papers and reports was presented, a number of business conferences and meetings was held, many inspection trips were taken, and a most complete entertainment program was offered.

Twenty-four papers and nineteen technical committee reports were presented in seven technical sessions. A summary of these sessions and their discussions is published in subsequent paragraphs of this report.

Conferences were held on June 24 under the auspices of the Sections Committee and the Committee on Student Branches. These were attended by Institute officers, Section Delegates, District representatives and other members. A report of these conferences is published in subsequent paragraphs.

The 1929 Annual Business Meeting of the Institute was held on the morning of June 25. After a short address of welcome by Hon. F. W. Cook, Secretary of State of the Commonwealth of Massachusetts, the official business of the meeting was transacted as reported elsewhere in this JOURNAL. The meeting concluded with an address by President R. F. Schuchardt, entitled "The Engineer, Practical Idealist." In this address, President Schuchardt touched on the opportunities and the responsibilities of the engineer to assume his appropriate place in our present changing civilization. His address is published on page 611 of this JOURNAL.

Another notable event was the presentation of the Lamme Medal on the evening of June 26. This medal was presented to A. B. Field to whom it was awarded as announced in the February JOURNAL, page 154 "for the mathematical and experimental investigation of eddy-current losses in large slot-wound conductors in electrical machinery." The medal was presented by C. F. Scott, Chairman of the Lamme Medal Committee. In addition to a response by the medalist there were short addresses by President R. F. Schuchardt, B. A. Behrend, and N. W. Storer. A more complete account of the presentation ceremonies is published elsewhere in this JOURNAL.

Following this, the John Scott Medal was also presented to Mr. Field. The presentation was made by National Secretary F. L. Hutchinson, acting on behalf of the Board of City Trusts of Philadelphia. The award was made for the same achievement for which the Lamme Medal was awarded to Mr. Field.

Dr. Elihu Thomson, Director of the Thomson Research Laboratory of the General Electric Co., was now introduced and he spoke very briefly about the fundamental electromagnetic relations discovered by Michael Faraday in 1831 the application of which during the last century has resulted in the development of modern electrical machines.

These medal presentations and addresses preceded a banquet; and an added feature which immediately followed the banquet was a brief talk by C. L. Edgar, President of the Edison Electric Illuminating Company of Boston. Mr. Edgar spoke on some of the pioneer steps in power system design which have been made by his company. W. F. Dawson, Chairman of the 1929 Summer Convention Committee, acted as toastmaster during the evening.

A most delightful popular lecture was given on the evening of June 25, by Dr. Harlowe Shapley, Professor of Astronomy at Harvard University and Director of the Harvard observatory. In a most interesting manner he told of some of the recent work in astronomy.

During the Convention, a very large number of inspection trips were taken to power plants, substations, telephone plants, factories, colleges, and points of historical and of scenic interest. Also, immediately after the Convention closed on June 28, a number of those present started on a three-day tour through the White Mountains.

Entertainment of the most enjoyable nature was offered throughout the meeting. Sports, dancing, and cards were enjoyed every day or evening. Golf, tennis, fishing, swimming, and trap shooting were partaken of by many. A particularly enjoyable event was an all-day outing on June 27 when a group of about 160 people traveled to Rye Beach, New Hampshire, where numerous field contests were held. A piano recital by Professor V. Karapetoff, with songs by Mrs. Underwood, contralto, was given on the evening of June 27.

Golf and tennis tournaments were played for the respective Mershon Cups. The winner of the golf tournament was W. S. Lee; G. S. Gibbs was the runner-up. In the tennis singles tournament, A. J. Gowan won first place while G. A. Sawin, Jr., won second. Prizes were given for various other competitions including several held at Rye Beach.

A meeting of the Board of Directors and several committee meetings were held during the Convention.

Much praise is due the local Summer Convention Committee for the excellence of arrangements and the high quality of the entertainment provided. This committee consisted of the following members who were officers of the committee or chairmen of other committees as indicated or general members: W. F. Dawson, *Chairman*; E. W. Davis, *Vice-Chairman*; H. B. Dwight, *Vice-Chairman*; C. S. Skoglund, *Vice-Chairman*; W. H. Colburn, *Secretary*; V. R. Holmgren, *Asst. Secretary*; F. L. Ball, *Treasurer*; H. P. Charlesworth, *Meetings and Papers*; W. B. Kouwenhoven, *Sections*; C. L. Edgar, *Finance*; C. A. Corney, *Trips*; F. S. Jones, *Transportation*; I. F. Kinnard, *Publicity*; W. E. Porter, *Hotel and Registration*; A. H. Sweetnam, *Sports*; Mrs. W. H. Timbie, *Ladies' Committee*; J. P. Alexander, G. J. Crowdes, W. S. Edsall, S. J. Eynon, J. W. Kidder, R. G. Porter, W. H. Pratt, Ernest Shorrock, D. F. Smalley, H. B. Wood.

CONFERENCE OF OFFICERS AND DELEGATES

In accordance with the practise followed since 1922, the first day of the Convention, Monday, June 24, was devoted to a Conference of Officers and Delegates held under the auspices of the Sections Committee and Committee on Student Branches. 49 of the 56 Sections were represented by Delegates. 5 District Secretaries and 8 representatives of District Committees on Student Activities were present. In addition to these official Delegates, a considerable number of Institute and Section officers, Branch Counselors, and other members were present.

The first session of the Conference was convened at 10:05 A. M., with Dr. W. B. Kouwenhoven, Chairman, Sections Committee, presiding. During the early part of the afternoon Sessions A and B were held in parallel, Dr. Kouwenhoven presiding over Session A, dealing with Institute and Section problems, and Vice-President J. L. Beaver, Chairman, Committee on Student Branches, presiding over Session B, dealing with Student Activities. During the latter part of the afternoon the two groups met together again to discuss matters of common interest.

The topics included in the program, which had been prepared

in advance by a special committee and mailed to the Delegates, are given below.

Announcements by Dr. W. B. Kouwenhoven, Chairman, Sections Committee.

Remarks by President Schuchardt.

Remarks by Presidential Nominee Smith.

Remarks by National Secretary Hutchinson.

The Institute Membership
- (a) The Responsibility of the Sections to the Question of Institute Membership.
- (b) The Policy Underlying the Securing of New Members.
- (c) How May the Proportion of Membership in Higher Grades be Increased?

The Institute Publications
- (a) What Changes Should be Made in the Present Institute Publications? (See A. I. E. E. JOURNAL, January 1929, page 2).
- (b) Can Papers be Published More in Advance of Presentation?

The Institute Section
- (a) How Can the Institute Section Help the Members in Expressing Their Obligations to the Public?
- (b) How May Cooperation Between the Section and Branches in the Same Locality be Increased?
- (c) How May Contact be Made between the Section and Student Members Coming into the Section Territory?

AFTERNOON SESSIONS

SESSION A—Dr. W. B. Kouwenhoven, Chairman.
- (a) "Regional" or "District" Meetings?
- (b) How Can Attendance at Section Mee ings be Increased?
- (c) The Establishment of Additional Engineering Societies.
- (d) Questions and Answers Relative to Institute Affairs.

SESSION B—Professor J. L. Beaver, Chairman.
- (a) The Transfer of Student to Associate.
- (b) Compulsory Attendance at Student Branch Meetings as part of Curriculum. How Much Time and Participation in Branch Programs can be expected of Students, and should the Faculty be asked to give Credit for this Work?
- (c) Status of Local Members in the Branch.

GENERAL SESSION—Dr. Kouwenhoven presiding.

The Post College Education of Engineers—Professor E. Bennett (See A. I. E. E. JOURNAL, April 1929, page 310, and Foreword by President Schuchardt).

Discussion.

Copies of the Annual Report on Section and Branch Activities for the fiscal year ending April 30, 1929, were distributed at the Conference. Institute members may secure copies by applying to headquarters.

The following recommendations were adopted:

1. That provisions be made encouraging enrolled Students to become Associates upon graduation and remitting dues in part, according to some suitable plan to be developed by a special committee.

2. That the conventions held in individual Districts and heretofore designated as "Regional Meetings" be called "District Meetings" in the future.

3. That consideration be given to the desirability of having the appropriation year for Sections begin August 1 instead of October 1.

At a meeting of the Board of Directors held at the Convention on June 25, these recommendations were considered favorably, and were referred to the proper committees and officers for study as to details.

In addition to the session on Monday afternoon, the Counselor Delegates and others especially interested in Student Activities held a session Monday evening for further discussion of the subjects given in the program for Session B and related matters. They recommended that headquarters send to each Counselor about February 1 a list of names of the enrolled Students of the Institute in his institution, indicating those who had and those who had not paid their enrolment fees for the current year.

An abstract of the proceedings of the entire Conference will be printed in pamphlet form and mailed to all Delegates present and to Institute, Section, and Branch officers. Any Institute member who is interested may obtain a copy of the pamphlet without charge upon application to Institute headquarters.

REPORT OF TECHNICAL DISCUSSION

The following is a condensed report of discussion at the technical sessions, together with the titles of the papers at each session. Complete discussion will be published with the respective papers in the TRANSACTIONS.

A—Distribution and Power Generation

Presiding Officers:

H. A. Kidder, Vice-President, A. I. E. E.

F. A. Allner, Chairman of Committee on Power Generation

H. R. Woodrow, Chairman of Committee on Power Transmission and Distribution

Rehabilitation and Rebuilding of Steam Power Plants, C. F. Hirshfeld, Detroit Edison Co.

Symposium on *Synchronized at the Load*

I. *A Fundamental Plan of Power Supply*, A. H. Kehoe, United Electric Light & Power Co.

II. *Calculations of System Performance*, S. B. Griscom, Westinghouse Electric & Mfg. Co.

III. *System Tests and Operating Connections*, H. R. Searing and G. R. Milne, United Electric Light & Power Co.

Automatic Transformer Substations of Edison Electric Illuminating Co. of Boston, W. W. Edson, Edison Elec. Ill. Co. of Boston

Application of Induction Regulators to Distribution Networks, E. R. Wolfert and T. J. Brosnan, Westinghouse Electric & Mfg. Co.

In discussing Mr. Hirshfeld's paper, E. S. Fields told how power-station changes on the system of the Columbia Gas & Electric Corp. had increased the capacity by 105,000 kw. without necessitating any building additions. Four 25,000-kw. turbo generators were changed by minor rebuilding of the turbines and putting in new 36,000-kw. generators. Steam pressure was raised from 230 to 250 lb. and temperature from 600 to 700 deg. In another station 45,000-kw. tandem-compound turbines were rebuilt as 65,000-kw. cross-compound. Steam pressure was raised from 600 to 650 lb. and temperature from 725 to 740 deg. The boilers were changed to give greater output and electrical equipment was changed to take care of the increased turbine output. W. S. Lee brought out the advantage of placing generating stations at the proper points in relation to the load. He warned against the assumption that high steam pressure is a panacea for all troubles. W. J. Foster declared that the rehabilitation of old hydraulic generators is often more profitable than that of steam-turbine generators, a 50 per cent increase in output being sometimes feasible. L. W. W. Morrow pointed out that enormous increases in thermal economy of steam stations have been made in the last twenty years (from 32,000 B. t. u. in 1908 to 12,000 B. t. u. in 1928) and this has been accomplished without materially increasing the investment cost per kw. capacity which has remained at about $100 as an average.

As an addition to the symposium on *Synchronized at the Load* G. R. Milne presented some operating data on the system described. He said no major trouble had been experienced during four months of operation. Voltage dips at the load have been reduced 50 per cent. A phase-to-neutral fault on the reserve bus at Hell Gate Station caused little disturbance. The voltage at the load dropped only 8.7 per cent. E. E. Chilberg mentioned the advantages of using double-winding generators with this

scheme of connection. R. H. Tapscott stated that the New York Edison Company is installing a 160,000-kw. double-winding generator. In a written discussion E. C. Stone stated that the advantages of the synchronized-at-the-load scheme cannot well be applied to the system of the Duquesne Light Co. because there would be only two transmission lines per generating unit and the failure of one would cause a relatively great disturbance. Moreover a large proportion of the load is supplied at 22,000 and 11,000 volts, which would also be disadvantageous in the new scheme.

B—Transportation

Presiding Officers:

E. B. Merriam, Vice-President, A. I. E. E.

N. W. Storer, Past-Chairman of Committe on Transportation

Electrification of the Mexican Railway, J. B. Cox, General Electric Co.

Contact Wire Wear on Electric Railroads, I. T. Landhy, Illinois Central Railroad Co.

An Electrified Railroad Substation, J. V. B. Duer, Pennsylvania Railroad

D-C. Railroad Substations, A. M. Garrett, Commonwealth Edison Co.,

In discussing Mr. Cox's paper, D. C. Jackson emphasized the need of actual records instead of estimates on the costs of electrification and electric operation. Sidney Withington stated that he would like to see Mr. Cox's comparison include also the most modern steam locomotive. W. B. Potter pointed out that the electric locomotives require considerably less maintenance than steam locomotives. He stated that the locomotive is by far the most important part of an electrification project.

In connection with Mr. Landhy's paper, Sidney Withington emphasized the necessity for the development of a suitable means of lubricating a contact wire. He stated that in Europe lower pantographs pressures (7 or 8 lb.) are used with pantographs having a light auxiliary bow which carries the shoe. He said that certain results led him to believe that current density affects trolley wear. C. S. Anderson stated that cadmium bronze wire wears better than other contact wires and that it does not become brittle In answer to a question, Mr Landhy and several others agreed that a double contact shoe is better than a single shoe because one element of the double shoe is in contact with the wire almost all the time which eliminates destructive arcing.

In answer to a question on his paper Mr. Garrett said that rectifiers and rotary converters can be paralleled very satisfactorily.

C—Technical Committee Reports

Presiding Officer:

J. L. Beaver, Vice-President, A. I. E. E.

Research, F. W. Peek, Jr., Chairman

Electrophysics, V. Karapetoff, Chairman

Education, Edward Bennett, Chairman

Instruments and Measurements, Everett S. Lee, Chairman

Communication, H. W. Drake, Chairman

Power Generation, F. A. Allner, Chairman

Power Transmission and Distribution, H. R. Woodrow, Chairman

Protective Devices, E. A. Hester, Chairman

Automatic Stations, W. H. Millan, Chairman

In discussing the report of the Committee on Education F. C. Caldwell suggested that attention should be directed toward schools which give slightly lower courses than the engineering colleges, with less theoretical studies. Charles Ficklenburg advocated more thorough teaching of mechanical structures.

In connection with the report of the Committee on Instruments and Measurements F. A. Wolff, advocated the development of concrete standard units simultaneously with absolute units.

Commenting on the report of the Committee on Automatic Stations, Chester Lichtenberg drew attention to the need for standardizing voltage on supervisory control systems. H. P. Sleeper made a plea for the keeping of complete records of operating results in automatic stations.

D—Technical Committee Reports

Presiding Officer:

O. J. Ferguson, Vice-President, A. I. E. E.

Electrical Machinery, W. J. Foster, Chairman

General Power Applications, J. F. Gaskill, Chairman

Transportation, W. M. Vandersluis, Chairman

Applications to Iron and Steel Production, M. M. Fowler, Chairman

Applications to Mining Work, Carl Lee, Chairman

Applications to Marine Work, W. E. Thau, Chairman

Electrochemistry and Electrometallurgy, George W. Vinal, Chairman

Electric Welding, A. M. Candy, Chairman

Production and Application of Light, B. E. Shackelford, Chairman.

Commenting on the report of the Committee on Electrical Machinery W. J. Foster emphasized some of the advantages of hydrogen ventilation. C. J. Fechheimer explained the advantages of the double-entrance fan.

Edwin Fleischman, in connection with the report of the Committee on Electrochemistry and Electrometallurgy, called attention to the advantages of the nitriding process of hardening the surface of steel objects. Electric furnaces are employed in this process. J. C. Lincoln explained a method of nickel plating, called the degasification process, in which nickel is deposited to a thickness of 1/16 in. after which the plated piece may be rolled to 1/4 its thickness.

In connection with the report of the Committee on Electric Welding, J. C. Lincoln said that his company uses electric welding in making many kinds of electrical machinery, and that the cost is considerably less than that of the older methods employing casting.

E—Miscellaneous

Presiding Officers:

B. D. Hull, Vice-President, A. I. E. E.

H. W. Drake, Chairman of Committee on Communication

J. F. Gaskill, Chairman of Committee on General Power Applications

Master Reference System for Telephone Transmission, W. H. Martin, American Tel. & Tel. Co., and C. H. G. Gray, Bell Telephone Laboratories, Inc.

Electrical Wave Analyzers for Power and Telephone Systems, R. G. McCurdy and P. W. Blye, American Tel. & Tel. Co.

A New Automatic Synchronizer, F. H. Gulliksen, Westinghouse Electric & Mfg. Co.

High-Frequency Portable Electric Tools, C. B. Coates, Chicago Pneumatic Tool Co.

Design of Electric Heating Elements, Edwin Fleischmann, The Niagara Falls Power Co.

J. J. Smith and J. O. Coleman stated that they had used the wave analyzers described in the McCurdy and Blye paper and had found them very useful and satisfactory.

In discussing Mr. Coates' paper, A. M. MacCutcheon emphasized the fact that 5 to 7 hp. is developed in 50 lb. of material in the high-speed tools and this weight includes all mechanical parts. He described a type of frequency converter which he said gives excellent voltage regulation. It consists he said of a rotating member into which alternating current is fed through slip rings. The output is taken from a commutator. The output frequency varies with the speed of rotation. F. L. Snyder pointed out that the induction frequency changer is usually less expensive than the motor-generator frequency changer. He suggested also that where distribution distances are great, the 180-cycle energy might be distributed at 440 volts and stepped down to 110 volts at the tool. B. B. Ramey stated that ventila-

tion of the tool is more easily accomplished with the 180-cycle tools than with 60-cycle universal motors. He suggested that power companies might in the future supply 180-cycle energy from their lines. Mr. Coates said that about 60 per cent of the present installations use the induction converter and 40 per cent use the motor generator.

F—Electrical Machinery

Presiding Officers:

W. T. Ryan, Vice-President, A. I. E. E.

W. J. Foster, Chairman of Committee on Electrical Machinery

Safe Loading of Oil-Immersed Transformers, E. T. Norris, Ferranti, Limited

Induction Motor Operation with Non-Sinusoidal Impressed Voltages, L. A. Doggett and E. R. Queer, Pennsylvania State College

Outdoor Hydrogen-Ventilated Synchronous Condensers, R. W. Wieseman, General Electric Co.

Short-Circuit Torque in Synchronous Machines Without Damper Windings, G. W. Penney, Westinghouse Elec. & Mfg. Co.

Analytical Determination of Magnetic Fields, B. L. Robertson, Pennsylvania State College, I. A. Terry, General Electric Co.

Commenting on the paper by Mr. Norris, F. F. Brand drew attention to the fact that large transformers with hot-spot indicators have been in service in America for a number of years. He claimed that the A. I. E. E. rules are not too conservative in limiting temperature as an operating temperature lower than 105 deg. is desirable to insure long life of insulation and oil. W. F. Dawson said it would be dangerous to apply the proposal of Mr. Norris to turbo alternators. W. M. Dann stated that many American operators are well satisfied with the margin of safety which the A. I. E. E. rules insure. He said, however, that the Institute is working on recommendations for operation of transformers by temperature. V. M. Montsinger claimed that some of Mr. Norris' calculations did not seem sufficiently accurate. He also objected to establishing 105 deg. cent. as a safe temperature for continuous operation. He thought that according to present knowledge 95 deg. by hot-spot indicator should be the limit. F. D. Newbury stated that sufficient records are not available to prove that the A. I. E. E. rules are too conservative and that therefore the present limitations should be kept to allow a margin of safety.

Commenting on the paper by Messrs. Doggett and Queer, R. G. McCurdy stated that usually the harmonics produced by receiving apparatus are greater than those put out by the generators.

Philip Sporn, in connection with Mr. Wieseman's paper, stated that generators offer the next opportunity for ventilation by hydrogen. This, he said, may facilitate the design of higher-voltage generators and of outdoor generators. C. J. Fechheimer explained that although the construction of a hydrogen-ventilated generator would be more difficult than a converter, the explosion danger would be very small and that previous use of a scavenging gas will minimize this difficulty. He said he believed the cost of a hydrogen-ventilated generator would be less than that of an air-cooled generator of the same rating. L. A. Doggett said it might be desirable to keep the air outside the machine in circulation so as to avoid explosions there. B. A. Behrend pointed out that another method of cooling stators of rotating machines is by means of oil. This is being tried in England, he said. He mentioned the advantages of using non-corrosive alloys for outdoor machines. F. D. Newbury stated that the danger of explosion is very small even with machines made without the precautions taken by Mr. Wieseman. A hydrogen-cooled generator he said will be perfectly safe indoors.

K. A. Reef explained how the solutions given in Messrs. Robertson's and Terry's paper might be applied to more general cases of slot design for d-c. machines.

G—Symposium on Shielding in Electrical Measurements

Presiding Officer:

E. S. Lee, Chairman of Committee on Instruments and Measurements

1. *Shielding and Guarding Electrical Measuring Apparatus*, H. L. Curtis, Bureau of Standards
2. *Some Problems in Dielectric Loss Measurements*, C. L. Dawes, P. L. Hoover and H. H. Reichard, Harvard University
3. *Shielding in High-Frequency Measurements*, J. G. Ferguson, Bell Telephone Laboratories
4. *Shielding of Cables in Dielectric Loss Measurements*, E. H. Salter, Elec. Testing Laboratories
5. *Precautions Against Stray Magnetic Fields in Measurements with Large Alternating Currents*, F. B. Silsbee, Bureau of Standards
6. *Magnetic Shielding in Electrical Measurements*, S. L. Gokhale, General Electric Co.

Several of the discussors complimented Dr. Curtis on his definitions of shielding and guarding. W. B. Kouwenhoven described an air condenser which he has developed which has very low loss. Humidity above 90 per cent he said will cause errors. I. M. Stein suggested that a standard condenser be built, probably by the Bureau of Standards, which can be transported from one laboratory to another.

L. E. Cirella said that he had been using a bridge like the one described by Messrs. Dawes, Hoover and Reichard and that most of the difficulties had been avoided. H. W. Lamson suggested that a tuned detector might prove useful in Professor Dawes' work. P. H. Humphries presented a mathematical derivation of the bridge equations and an analysis of the conditions for balance of the bridge described in Professor Dawes' paper. C. T. Weller asked if capacitance is as satisfactory as resistance for the bridge arms. T. F. Peterson gave some information on the high-voltage bridge which has been developed by H. J. Ryan at Stanford University. V. A. Thielman disagreed with the contention of the authors that shielding of a cable may increase power factor and loss.

P. S. Bower called attention to the difficulty of determining equivalent inductance and capacitance at high frequencies.

In connection with Mr. Salter's paper, E. W. Davis pointed out the deleterious effects of voids in cables. D. W. Roper mentioned tests which he is making on samples of several makes of single-conductor cable in which inductive effects in the lead sheath must be compensated for. Mr. Salter stated that for two years his results obtained on 10-ft. samples have checked very closely with factory measurements on full reels.

S. L. Gokhale, in referring to Doctor Silsbee's paper, told of a method he employs to compensate for a stray magnetic field that is not uniform. Doctor Silsbee agreed that the results were desirable but that the method might be complicated.

Hans Lippelt complimented Mr. Gokhale's treatment of magnetic shields and added further details on some points.

ANNUAL MEETING OF THE INSTITUTE

Swampscott, Mass., June 25, 1929

The Annual Meeting of the Institute was held at the New Ocean House, Swampscott, Massachusetts, on Tuesday morning, June 25, 1929, during the annual Summer Convention, President R. F. Schuchardt presiding.

The Annual Report of the Board of Directors was presented in abstract by National Secretary F. L. Hutchinson. Printed copies were distributed to members in attendance and are available to any member upon application to Institute Headquarters, New York. The report, which constitutes a resume of the activities of the Institute during the fiscal year ending April 30, 1929, showed a total membership on that date of 18,133. In addition to the three National conventions and three Regional meetings, 1400 meetings were held during the year by the local organizations of the Institute in the principal cities and educational institutions in the United States and Canada.

The report will be published in full in the quarterly TRANSACTIONS of the Institute.

The report of the Committee of Tellers on the election of officers of the Institute was presented as published in the July issue of the JOURNAL, and in accordance therewith, President Schuchardt declared the election of the following officers, whose terms will begin on August 1, 1929:

President: HAROLD B. SMITH, Professor of Electrical Engineering and Director of the Department, Worcester Polytechnic Institute, Worcester, Mass. (See biographical sketch in July issue of the JOURNAL, p. 564.)

Vice-Presidents: EDMUND C. STONE, Manager, System Development Department, Duquesne Light Co., Pittsburgh, Pa.

WALTER S. RODMAN, Professor in charge of the School of Electrical Engineering at the University of Virginia, Charlottesville, Va.

HERBERT S. EVANS, Dean, College of Engineering and Head of the Department of Electrical Engineering at the University of Colorado, Boulder, Colorado.

CLARENCE E. FLEAGER, Assistant Vice-President, Pacific Tel. & Tel. Co. San Francisco, Calif.

CHARLES E. SISSON, Transformer Engineer, Canadian General Electric Company, Ltd., Toronto, Ontario, Canada.

Directors: JOHN E. KEARNS, Electrical Engineer, General Electrical Co., Chicago, Ill.

WILLIAM S. LEE, Consulting Engineer, Charlotte, North Carolina.

CHARLES E. STEPHENS, North Eastern District Manager, Westinghouse Electric & Mfg. Company, New York.

National Treasurer: GEORGE A. HAMILTON, Elizabeth, N. J., (re-elected).

These officers, together with the following hold-over officers, will constitute the Board of Directors for the next administrative year, beginning August 1: R. F. Schuchardt (retiring President), Chicago, Ill.; Bancroft Gherardi, New York, N. Y.; E. B. Merriam, Schenectady, N. Y.; H. A. Kidder, New York, N. Y.; W. T. Ryan, Minneapolis, Minn.; B. D. Hull, Dallas, Texas; G. E. Quinan, Seattle, Wash.; I. E. Moultrop, Boston, Mass.; H. C. Don Carlos, Toronto, Ont.; F. J. Chesterman, Pittsburgh, Pa.; F. C. Hanker, East Pittsburgh, Pa.; E. B. Meyer, Newark, N. J.; H. P. Liversidge, Philadelphia, Pa.; J. Allen Johnson, Niagara Falls, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; A. E. Bettis, Kansas City, Mo.

President-elect Smith was called upon and responded with a brief address which was enthusiastically received.

The report of the Committee on Award of Institute Prizes, as published in the June issue of the JOURNAL, was read by the Chairman H. P. Charlesworth and prizes for papers presented during 1928 were presented by President Schuchardt.

The annual presidential address was then delivered by President Schuchardt, the subject being "The Engineer, Practical Idealist." This address is published in full on page 611 of this issue.

The Annual Meeting then adjourned and was immediately followed by technical sessions as reported elsewhere in this issue.

The Chicago Regional Meeting in December

A three-day regional meeting will be held in Chicago, December 2-4, 1929, under the auspices of the Great Lakes District of the Institute.

Four technical sessions are being planned, the general subjects of which will be power stations, transmission and distribution, communication, and general research and development. There will also be Student meetings. Of details, later issues of the JOURNAL will give more.

The Lamme Medal

THE 1929 NOMINATIONS FOR THE 1929 AWARD WILL BE RECEIVED UNTIL SEPTEMBER 1

The Lamme Medal was founded as a result of a bequest of the late Benjamin G. Lamme, Chief Engineer of the Westinghouse Electric & Mfg. Company, who died July 8, 1924, to provide for the award by the Institute of a gold medal (together with bronze replica thereof) annually to a member of the A. I. E. E. "who has shown meritorious achievement in the development of electrical apparatus or machinery," and for the award of two such medals in some years if the accumulation from the funds warrants.

The first (1928) Lamme Medal has been awarded to Allan Bertram Field, Consulting Engineer, Metropolitan Vickers Electrical Company, Ltd., Manchester, England, "for the mathematical and experimental investigation of eddy current losses in large slot-wound conductors in electrical machinery," and was presented during the Summer Convention at Swampscott, Mass., June 24-28.

Special attention is called to the fact that names of members of the Institute, who are considered suitable candidates for the Lamme Medal to be awarded in the Fall of 1929, may be submitted by any member in accordance with Section 1 of Article VI of the By-laws of the Lamme Medal Committee, which is quoted below:

"The Committee shall cause to be published in one or more issues of the A. I. E. E. JOURNAL each year, preferably including the June issue, a statement regarding the 'Lamme Medal' and an invitation for any member to present to the National Secretary of the Institute by September 1 the name of a member as a candidate for the Medal, accompanied by a statement of his 'meritorious achievement' and the names of at least three engineers of standing who are familiar with the achievement."

Each nomination should give concisely the specific grounds upon which the award is proposed, and also a complete detailed statement of the achievement of the nominee, which will enable the Committee to determine its significance as compared with those of other candidates. If the work of the nominee has been of a somewhat general character, in cooperation with others, specific information should be given regarding the contributions of the individual. Names of endorsers should be given as specified above.

Electrochemist to Discuss Aviation Materials

The American Electrochemical Society will hold its Fall Convention in Pittsburgh, Pa., September 19 to 21 inclusive to discuss, among other subjects, the chemical industry's contributions to aeronautics. Several hundred chemists, metallurgists, plant executives, and company officials of both the United States and Canada will be present to discuss recent developments in the electrochemical field.

The program will include visits to various industrial plants in the Pittsburgh district, and technical sessions with papers on pertinent subjects presented by various prominent men from all over the country. There will be a special symposium on "Contributions of Electrochemistry to Aeronautics," with emphasis given to the light weight aluminum and magnesium alloys used in aeroplane construction.

Social features of the meeting will include a smoker, a dinner and dance, with a special program for the ladies of the party. Headquarters will be at the William Penn Hotel, 5th Avenue and William Penn Way.

The Pacific Coast Convention

HAS NOTABLE PROGRAM ARRANGED FOR SEPTEMBER 3-6

GROUNDS OF HOTEL MIRAMAR, SANTA MONICA, CALIF., A. I. E. E. CONVENTION HEADQUARTERS

A program of unusual interest is planned for the coming Pacific Coast Convention of the Institute which will be held September 3-6, with headquarters at the Hotel Miramar, Santa Monica, Calif. Some live technical subjects will be discussed, and trips, sports, and entertainment will be enjoyed. The ladies who attend will be treated to some delightful events arranged especially for them.

The technical papers will deal with such subjects as transmission, insulator flashover, wood pole insulation strength, series synchronous condensers, system stability, high-voltage fuses, transformers, insulating oils, arc flames, electrical conductivity, gas-filled tubes, sound pictures, dial telephony, load forecasting, wind-tunnel equipment, turbo generators and a-c. networks.

There will also be two Student sessions at which twelve Student technical papers will be presented.

The program of events is shown in the following outline.

TENTATIVE PROGRAM

Morning, September 3

TECHNICAL SESSION

Radio Interference from Line Insulators, E. Van Atta, Pacific Power & Light Co., and E. L. White, Puget Sound Power & Light Co

Spray and Fog Tests on 200-Kv. Insulators, R. J. C. Wood, Southern California Edison Co.

The 60-Cycle Flashover of Long Suspension Insulator Strings, R. H. Angus, Stanford University.

Impulse Insulation Characteristics of Wood Pole Lines, H. L. Melvin, Electric Bond & Share Co.

Afternoon, September 3

STUDENT TECHNICAL SESSION

Experience with a Cathode-Ray Oscillograph in a College Laboratory, C. C. Lash, Graduate Student, California Institute of Technology.

Lichtenberg Figures, O. C. Mayer, University of Idaho.

Characteristics of Electrostatic Loud Speakers, F. J. Somers and George Mattos, University of Santa Clara.

Flashover Phenomena in High-Voltage Engineering, W. G. Hoover and Corbett McLean, Graduate Students, Stanford University.

Voltage Distribution on High-Tension Insulators, Floyd Gowans and Ned Chapman, University of Utah.

Voltage Amplification of the Screen-Grid Tube as an Intermediate-Frequency Amplifier, Frank Giovanini, Graduate Student, University of Washington.

Evening, September 3

Reception, followed by dancing.

Morning and Afternoon, September 4

Inspection Trips and Sports.

Evening, September 4

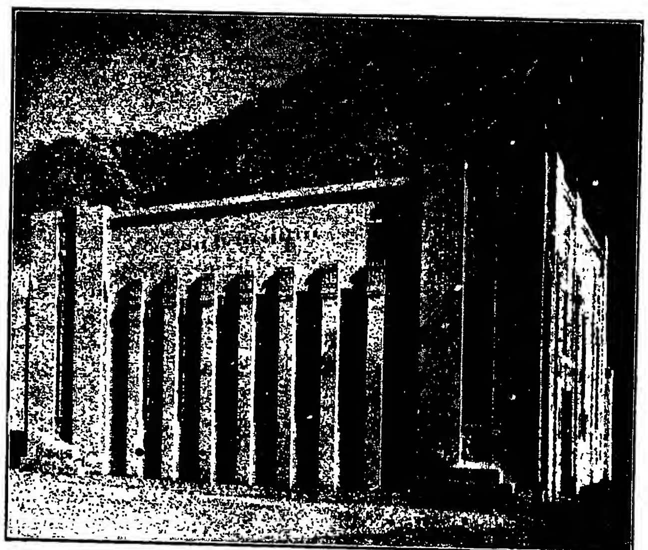
Lecture—"Recent Developments in the Theory of Electrical Conductivity," by W. V. Houston, California Institute of Technology.

Dancing will follow the lecture.

Morning, September 5

STUDENT TECHNICAL SESSION

Influence of Rotor Impedance on the Starting Characteristics of Squirrel-Cage Induction Motors, A. V. Haeff, Graduate Student, California Institute of Technology.



SAN FRANCISQUITO HYDROELECTRIC PLANT NO. 2 OF THE DEPARTMENT OF WATER AND POWER, CITY OF LOS ANGELES

The Heating of Copper Conductors by Transient Electric Currents, S. O. Rice, Oregon State College.

Cyclic and Transient Illumination of Incandescent Lamps as Measured by the Photoelectric Cell, Z. J. Atlee and R. W. Mige, Oregon State College.

Study of the Losses in a 25,000-Kv-A., A. C. Generator, J. G. Pleasants and M. Tucker, University of Southern California.

The Operation of Synchronous Motors in Series, C. R. Koch, Graduate Student, Stanford University.

Power Losses by Radiation from Domestic Hot-Water Tanks, R. D. Wailes, University of Washington.

Afternoon, September 5

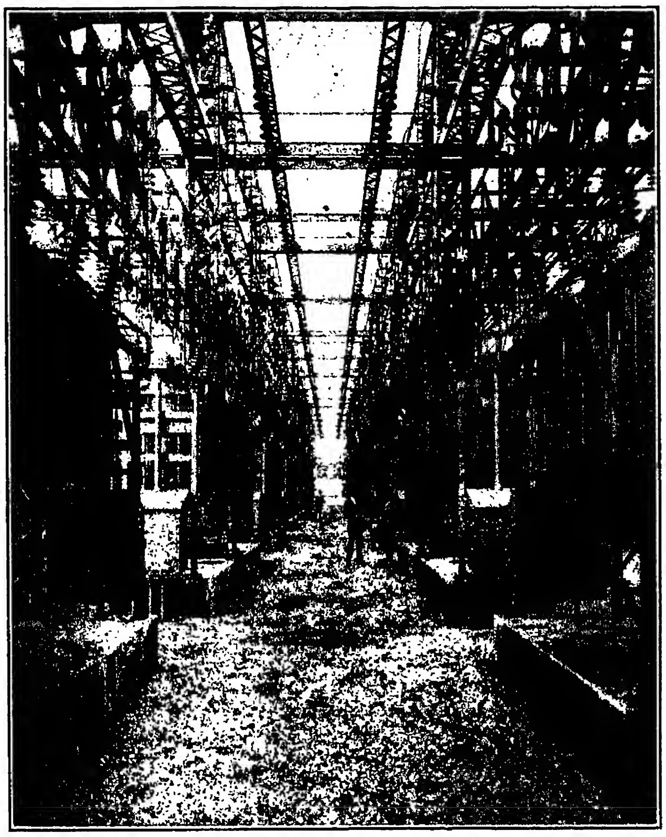
TECHNICAL SESSION

Development of Insulating Oils, C. E. Skinner, Westinghouse Electric & Mfg. Co.

Effect of Tank Color on Temperature of Transformers under Service Conditions, V. M. Montsinger and L. Wetherill, General Electric Co.

Population as an Index to Electrical Development, N. B. Hinson, Southern California Edison Co.

Flames from Electric Arcs, J. Slepian, Westinghouse Electric & Mfg. Co.



VIEW OF MAIN SWITCHING STATION (LAWRENCE STREET) OF LOS ANGELES GAS & ELECTRIC CORPORATION

Design Features that Make Large Turbine Generators Possible, W. J. Foster and M. A. Savage, General Electric Co.

Evening, September 5

Banquet, with special Entertainment.

Morning, September 6

TECHNICAL SESSION

Effects of Surges on Transformer Windings, J. K. Hodnette, Westinghouse Elec. & Mfg. Co.

An A-C. Low-Voltage Network without Network Protectors, L. R. Gamble and Earl Baughn, The Washington Water Power Co.

Low-Current High-Voltage Protective Equipment, Roy Wilkins, Pacific Electric Mfg. Corp.

Precision Speed Regulation for the Wind-Tunnel Motor at California Institute of Technology, W. A. Lewis, Jr., California Institute of Technology.

Afternoon, September 6

TECHNICAL SESSION

The Electrical Engineering of Sound-Picture Systems, T. E. Shea, Bell Telephone Laboratories and K. F. Morgan, Electrical Research Products Corp.

Dial Telephone System Serving Small Communities of Southern California, F. W. Wheelock, Southern California Telephone Co.

Parallel Operation of Transformers whose Ratios of Transformation are Unequal, Mable Macferran, Southern California Edison Co.

Progress in the Study of System Stability, I. H. Summers and J. B. McClure, General Electric Co.

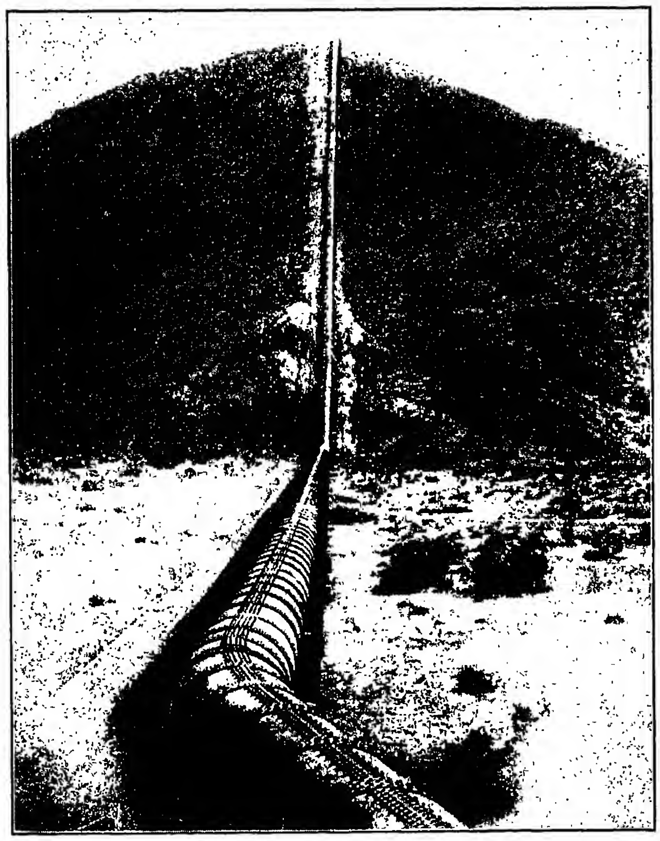
Series Synchronous Condensers for Transmission-Line Regulation, T. H. Morgan, Stanford University.

September 7 and 8

Trip to Mount Lowe.
Trip to Catalina Island.
Other trips as requested.

Trips

Automobile transportation will be furnished for trips to points of interest at all times except during convention sessions. For Wednesday, September 5, no sessions are scheduled and the entire day will be devoted to trips and sports. Trips have been arranged also for Saturday, September 7. The special trips are as follows:



JAWBONE SIPHON SECTION OF 250-MILE AQUEDUCT ALONG WHICH THE CITY OF LOS ANGELES HAS CONSTRUCTED FIVE POWER PLANTS AND IS GENERATING 166.000 HYDROELECTRIC HORSEPOWER

SEPTEMBER 5

Long Beach Steam Plant No. 3, Central Receiving Station, Lighthipe Substation, Seal Beach Steam Plant, and Wilmington Receiving Station.

Los Angeles Hydroelectric Plant; San Fernando Mission; and Pacoima Flood Control Dam.

San Bernardino Substation; Glenwood Mission Inn, Riverside; Hotpoint Factory at Ontario.

California Institute of Technology, Million-Volt Laboratory; and University of California at Los Angeles.

SEPTEMBER 7

Mount Lowe, via Pacific Electric R. R., round trip $3.00.
Power Plant and Substation Trips as requested.

SEPTEMBER 7 AND 8

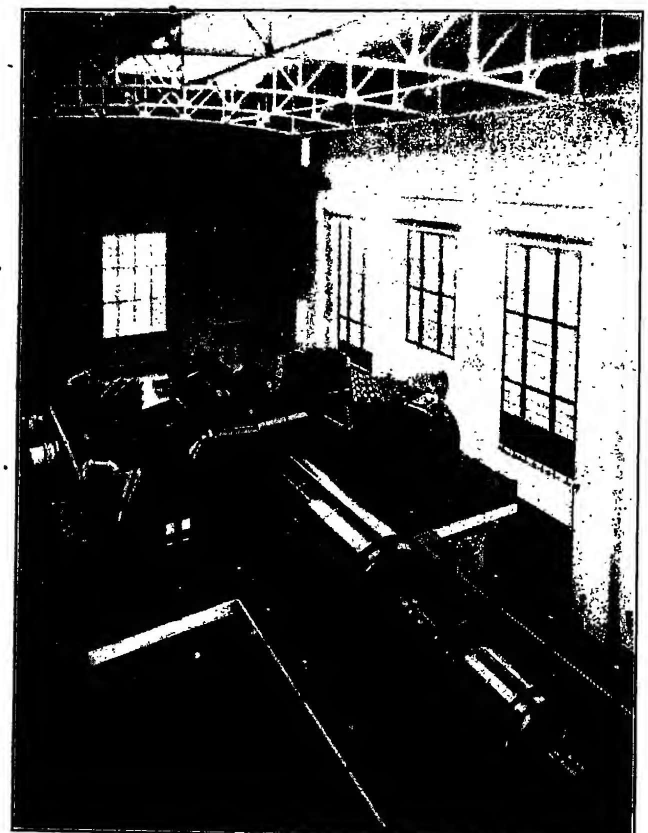
Catalina Island Trip,—all expenses paid including four meals and room at the St. Catherine Hotel—$12.50. Transportation only—$3.75.

Agua Caliente Trip,—visiting also Tijuana and San Diego. Transportation $10, if 20 or more go.

Trips will also be arranged to moving picture studios and if possible delegates will have the opportunity of seeing a talking picture in the making. Definite arrangements regarding studio trips will be announced later.

Golf

A golf tournament will be played at the Brentwood Country Club, which is a short distance from the Miramar and is considered one of the finest on the Coast. There will be numerous prizes for different classes of both low net and low gross scores; also the tournament will be played in classes, probably from



94,000 KW. GENERATOR UNIT OF SOUTHERN CALIFORNIA EDISON COMPANY, LONG BEACH

scratch to 16, 16 to 24, and 24 and over. There are numerous cups that will be played for, complete announcement of which will be made later.

Arrangements have also been made whereby guests may receive cards to practically all the leading clubs, such as the Los Angeles Country Club, Brentwood, Rancho, Bel-Air and Riviera.

Ladies Entertainment

Many enjoyable events have been planned for the entertainment of the ladies. On Tuesday, September 3 the visiting ladies will be taken in automobiles to interesting points in and around Los Angeles.

On Wednesday at noon there will be a ladies luncheon to honor Mrs. E. R. Northmore, with Mrs. H. L. Caldwell presiding.

Wednesday afternoon will be devoted to an informal reception with tea and cards, either at the Miramar Beach Club or at the Hotel.

On Thursday morning a ladies' putting contest will take place.

Other features are being arranged. Motion picture studio trips will be taken and the ladies will have the use of the Miramar Beach Club at all times.

Hotel Accommodations

Hotel reservations should be made directly with the Miramar Hotel, Santa Monica, Calif., Morgan S. Tyler, Resident Manager. Hotel rates are as follows:

For rooms in the main building and the cottages the rate is $3.50 per person per day. This rate is on the basis of double rooms with bath. The rooms are extra large. Double suites in the Annex will accommodate three or four, and single suites will accommodate two people, each suite with bath. The rates in the Annex are $3.00 per person per day.

The charges for meals are as follows: Club breakfast, 25 cents to $1.00; Luncheon, $1.00 and Dinner, $1.50. There is also a la carte service at reasonable prices.

The regular club privileges to the Miramar Beach Club will be extended to all guests at the convention, the only charge being for the rental of bathing suit and locker for use in surf bathing or in the heated salt-water pool. For convention delegates the rate will be 50 cents per person.

Railroad Rates

Summer excursion rates will be in effect at the time of the convention and those who attend may have the benefit of considerable reductions from the regular railroad fare.

Committees

A large local committee is actively engaged in completing arrangements. E. R. Northmore, Vice-President of the Institute in the Pacific District, is Convention Chairman, and H. L. Caldwell, Chairman of the Los Angeles Section is Assistant Convention Chairman. The chairmen of the various sub-committees are as follows: *Registration*, G. E. Nott; *Entertainment*, R. A. Hopkins; *Transportation*, H. H. Cox; *Hotels*, F. E. Dellinger; *Ladies Entertainment*, L. C. Williams; *Program, (Members)* E. R. Stauffacher, *Program (Students)* R. W. Sorensen; *Finance*, N. B. Hinson; *Publicity*, J. H. Cunningham; *Golf*, Harold Thrane.

STANDARDS

Three New Reports on A. I. E. E. Standards Availabl

The attention of the membership is again called to the availability of three reports on proposed A. I. E. E. Standards. The reports may be obtained without charge by addressing the Secretary of the Standards Committee at Institute headquarters. They are No. 2, Electrical Definitions and Symbols; No. 12, Constant Current Transformers; No. 27, Switchboards and Switching Equipment for Power and Light. A detailed statement regarding these proposed Standards appears on page 565 of the July JOURNAL.

Specifications for Weatherproof Wires and Cables

A subcommittee of the Sectional Committee on Insulated Wires and Cables has prepared a draft of proposed specifications on the above project. This draft also contains a section on Heat-Resisting Wires and Cables. The work of this committee is under the chairmanship of Mr. Thomas Sproule of the New Jersey Public Service Corporation. Copies of the draft are available at American Standards Association office, 33 West 39th St., New York, for loan to those interested.

This report takes up in detail the covering, size of conductor, and the saturating compound for weatherproof wires. The drip, bending, and melting tests of the saturated cable are explained in some detail. The draft contains a table of weights given in pounds per 1000 ft. of cables varying in size from 250,000 to 1,500,000 cir. mils.

The section relating to Heat-Resisting Wires and Cables gives the Flame Proofing Test and other material on fire proof cable.

Dry Cells

The Sectional Committee on this project is preparing revisions which relate to the American Standard C 18-1928 and to U. S. Government Master Specifications for Dry Cells and Batteries No. 58a. A recent meeting of a subcommittee held in Cleveland recommended tests for industrial flashlight cells, and for radio B batteries, and that a study be made for six months with a view to changing the existing minimum required performance figures for batteries other than radio B batteries. In the latter connection some of the proposed changes are:

		Present	Proposed
General purpose cells No. 6	Heavy intermittent	50 hours	60 hours
General purpose cells No. 6	Light intermittent	160 days	170 days
Telephone Cells	Light intermittent	190 days	220 days
Radio A Cells	Light radio test	210 hours	225 hours
Flashlight Cells C	Intermittent test	170 min.	210 min.
Flashlight Cells C	Delayed Service three months	70 min.	80 min.
Flashlight Cells E	Intermittent Test	650 min.	750 min.
Flashlight Cells E	Delayed Service six months	420 min.	450 min.

Mr. G. W. Vinal of the Bureau of Standards, Washington, D. C., is Chairman of the Sectional Committee in charge of the revision of this standard, and comments or criticisms may be sent to Mr. Vinal.

Symbols for Photometry and Illumination

The sectional committee on Scientific and Engineering Symbols and Abbreviations has submitted to the sponsors a draft of a proposed standard developed by a subcommittee under the chairmanship of Mr. Frank Benford, Illiminating Engineering Laboratory, General Electric Company.

This draft, covering symbols for photometry and illumination, consists of 15 symbols covering such terms as radiant flux, quantity of light, and reflection factor. Copies of this draft are available for loan to those interested through the American Standards Association headquarters, 33 West 39th Street, New York.

The American Standards Association

In view of the fact that the first meeting of the Board of Directors of the American Standards Association was held on July 9 a short review of the history and purposes of this organization may be of interest.

American Engineering Standards Committee was set up in 1917 by a group composed of the A. I. E. E., the A. S. M. E., the A. S. C. E., the A. I. M. E., and the A. S. T. M., to provide a systematic method of bringing about the cooperation of bodies engaged in standardization; to prevent duplication; to determine whether new projects should be undertaken; and to ultimately affix the stamp of "American Standard" to completed projects after a thorough examination has shown such action warranted.

To keep in step with the rapid increase in industrial standardization, the American Standards Association, or as it was originally called the American Engineering Standards Committee was reorganized in 1928. At the time of the reorganization, the Association had grown to 37 member bodies, with an additional three hundred and fifty sustaining members, including manufacturers, distributors, associations, etc. The reorganization has placed the technical work of approving standards in a "Standards Council" and concentrated the administrative and financial responsbility in a "Board of Directors" composed of twelve industrial executives. The underlying principles of the original A. E. S. C. remain unchanged. The basic functions remain completely in the hands of the member bodies who name the individual members of the Board of Directors and of the Standards Council. The present Board of Directors is composed of the following: Quincy Bent, Vice-President, Bethlehem Steel Company; G. K. Burgess, Director, Bureau of Standards; C. M. Chapman, Consulting Engineer; C. L. Collens, President, Reliance Elec. & Engg. Co.; Howard Coonley, President, Walworth Mfg. Co.; L. A. Downs, President, Illinois Central System; Bancroft Gherardi, Vice-President, American Tel. & Tel. Co.; F. E. Moskovics, President, Improved Products Co.; W. J. Serrill, Chairman of Research Committee, U. G. I. Co.; C. E. Skinner, Asst. Director of Engineering, Westinghouse Elec. & Mfg. Co.; M. S. Sloan, President, New York Edison Co.; R. J. Sullivan, Vice-President, Travelers Insurance Co.

An agreement has just been reached between the American Standards Association and the Bureau of Standards outlining the cooperative relation of the two bodies in reference to commercial standards. The National Bureau of Standards, through its Division of Trade Standards, is acting as a centralizing agency for industrial and commercial groups requesting its cooperation in the adjustment, application, and promotion of standards that will facilitate production and marketing of the commodities which concern the requesting group. After proper acceptance of such standards by the interests immediately concerned, the Bureau publishes them as the "Commercial Standards" of those interests. Primarily, the effort of the Bureau is to serve those groups which have no satisfactory standardization facilities. Since "Commercial Standards" are obviously of interest to groups immediately concerned with the manufacturing and marketing of specific commodities, such standards are not considered to have the same status as is imparted to standards approved as American Standards by the A. S. A., though it is hoped that some Commercial Standards will eventually receive such approval. Commercial standards are temporary standards.

Highway Research Board to Meet in December

The Ninth Annual Meeting of the Highway Research Board will be held December 12-13, in Washington, D. C., at the building of the National Academy of Sciences and National Research Council.

An important feature of the meeting will be the presentation of progress reports upon the comprehensive program of highway research now in preparation by the Board.

AMERICAN ENGINEERING COUNCIL

SPECIAL COMMITTEE TO WORK WITH CONGRESS AND FEDERAL ADMINISTRATION

Organization for 1929 of more than a score of committees to work with Congress and the Federal administration in shaping public policies involving vast engineering operations is announced by the American Engineering Council. Communications, flood control, safety of dams, water resources, and Government reorganization are among the chief problems to be studied.

At a meeting of the Council's Administrative Board to be held in Washington in October, these committees will submit reports reflecting the engineering attitude toward legislation arising at the next session of Congress.

With an engineer in the White House, and a growing representation of engineers in public posts,—national, state, and municipal,—the Council, according to an announcement by its President, Arthur W. Berresford, has framed what is believed to be the most helpful program of cooperation with public agencies in the history of American engineering.

The results, he adds, should enable the Government to function more intelligently in engineering projects requiring annually the expenditure of millions of dollars. Mississippi flood control is

cited as one of many situations which need clarification by the civil engineer.

D. Robert Yarnall of Philadelphia is Chairman of the Public Affairs Committee. Public questions affecting engineers generally will come before this Committee, other members of which have been chosen as follows: J. L. Hamilton, St. Louis; John Lyle Harrington, Kansas City, Mo.; H. A. Kidder, New York City; W. S. Lee, Charlotte, N. C.; R. C. Marshall, Jr., Chicago; Charles Penrose, Philadelphia; R. F. Schuchardt, Chicago; C. E. Skinner, East Pittsburgh, Pa.; Max Toltz, St. Paul, Minn.; Edwin F. Wendt, Washington, D. C.

A new Committee on Communications, to study proposed legislation for Federal supervision of such means of communication as radio, telephone, and telegraph, is headed by Edwin F. Wendt, of Washington. It will study fundamental questions raised by the Watson and Couzens Bills. Other members are: O. H. Caldwell, New York, Federal Radio Commissioner; Dean Dexter S. Kimball, Cornell University; Frank A. Scott, Cleveland; Charles B. Hawley, Washington, D. C.

Gardner S. Williams of Ann Arbor, Mich, is Chairman of a Committee on Flood Control. Mr. Williams also heads Committees on Government Reorganization and the Safety of Dams.

Chairmen of other Committees of the Council include:

Power—Farley Osgood, New York; Reforestation—William Boss, University of Minnesota; Street and Highway Safety—M. M. Fowler, Chicago; Recent Economic Changes—Dean Dexter S. Kimball, Cornell University; Engineering and Allied Technical Professions—H. C. Morris, Washington; Regional Activities, and Membership and Representation—O. H. Koch, Dallas, Tex.; Program of Research—Dr. Harrison E. Howe, Washington; Man-Hour Information, and Constitution and By-Laws—L. P. Alford, New York; Patents—Edwin J. Prindle, New York; National Hydraulic Laboratory—Farley Osgood, New York; Washington-Potomac Canal—D. H. Sawyer, Washington; Finance—John H. Finney, Washington; Representation—A. W. Berresford, New York.

NICARAGUAN INTEROCEANIC CANAL BOARD APPOINTED

By authority received from the Edge Resolution, Publ. Res. 99, of the 70th Congress, President Hoover has appointed a Nicaraguan Interoceanic Canal Board composed of the following five members:

General Edgar Jadwin, Chief of Engineers, U. S. A., Chairman; Major Ernest Graves, U. S. Engineers; Doctor Anson Marston, President, American Society of Civil Engineers; Frank M. Williams; and Sidney B. Williamson. Three members of this board are engineers from civilian life, and four are members of the American Society of Civil Engineers, a member organization of American Engineering Council. Lieut. J. P. Dean has been chosen Secretary to the Board.

Not only will the Board investigate the feasibility, desirability, and cost of increasing the facilities of the Panama Canal, but it will investigate and bring up-to-date the data on the Nicaraguan Canal route and any other routes considered in the opinion of the Board worthy of consideration.

Costa Rica and Nicaragua have given their consent to the preliminary surveys and operations of the troops and survey parties within their territories for this purpose. President Hoover has authorized the dispatch to Nicaragua of a battalion of engineer troops to make the investigation and survey.

PLEA FOR MAPPING APPROPRIATIONS

At the last meeting of the Administrative Board of American Engineering Council, a plea for increased appropriations for mapping facilities was again instructed. Hon. Robert P. Lamont, Secretary of Commerce, and Hon. Ray L. Wilbur, Secretary of Interior, were approached, having the work of the Coast and Geodetic Survey and the Geological Survey, respectively, coming under their jurisdiction.

In order to secure efficient and economic operation of all major engineering projects, including city surveys and planning, highway development and extension, irrigation projects, hydroelectric developments, improvement of rivers for navigation, flood control of rivers, and general topographic surveying and mapping, a knowledge of elevations and geographic positions is required.

According to the Board of Surveys and Maps of the Federal Government the completion of the fundamental leveling and triangulation needs of the country has been estimated to cost not in excess of five million dollars.

In the plea to the Secretary of Interior in behalf of the topographic survey American Engineering Council urged that hereafter the appropriations for topographic surveys be increased annually so as to complete the work of topographically mapping the United States in a period of 25 years as contemplated and authorized by the Temple Act, as it believes that the Federal Government engages in no more important work than that of making available accurate topographical maps.

COLORADO RIVER PROJECT PROGRESSES

As required by the Boulder Canyon Project Act, approved December 21, 1928, President Hoover has issued a public proclamation that all prescribed conditions have been fulfilled, and that the act is effective as of June 25, 1929. At the time of the signing of this proclamation, President Hoover stated that difficulties over the respective water rights of the different States have served to prevent development in a large way for nearly a quarter of a century. He considers this "the most extensive action ever taken by a group of States under the provisions of the Constitution permitting compacts between States," and hopes that Arizona and California may compose their mutual problems which have hitherto prevented Arizona from joining in the compact, for "with Arizona in, the whole Basin will have settled its major question of water rights for all time."

Secretary of the Interior Wilbur, in an address at Las Vegas, Nevada, on June 22, enunciated a new government policy with reference to the Colorado River project, stating that he would like to see the government come in and build reclamation projects, protect its investment through contracts that will pay the money back into the treasury and then withdraw from the field; not to become involved in situations purely local or those calling for intricate settling of tax problems and bond issues, or community and states rights.

L. C. Hill, A. S. C. E.; A. J. Wiley, A. S. C. E.; and W. F. Durand, Past-Pres., A. S. M. E., were chosen to act as special consultants in the field service of the U. S. Bureau of Reclamation in connection with the development of the Boulder Canyon Dam project.

Further information concerning the project may be secured by addressing the Commissioner of Reclamation, Washington, D. C.

WATER RESOURCES DIVISION NEEDS HELP

It has been the function of the U. S. Geological Survey since 1888 to systematically collect and make available data in regard to the water resources of the nation. This is an exceedingly useful service, and the only criticism which has been expressed has been that a sufficient amount of information has not been collected and made available. This has been due to insufficient appropriations by the Federal Government. The amount of work which has been completed to date would not have been realized had not State and local governmental agencies, individuals, and corporations supplied the U. S. Geological Survey with funds in addition to those appropriated by the Federal Government.

The Western Association of State Engineers, with a membership composed of 17 western States, has expressed itself in favor of the policy enunciated, and has designated American Engineering Council as its agent in regard to this matter.

A. I. E. E. Directors Meeting

The regular meeting of the Board of Directors of the American Institute of Electrical Engineers was held at the New Ocean House, Swampscott, Mass., on Tuesday, June 25, 1929, during the annual Summer Convention of the Institute.

There were present: President R. F. Schuchardt, Chicago, Ill.; Vice-Presidents: E. B. Merriam, Schenectady, N. Y.; J. L. Beaver, Bethlehem, Pa.; H. A. Kidder, New York, N. Y.; W. T. Ryan, Minneapolis, Minn.; O. J. Ferguson, Lincoln, Neb.; B. D. Hull, Dallas, Tex.; E. R. Northmore, Los Angeles, Calif.; A. B. Cooper, Toronto, Ont.; Directors: A. E. Bettis, Kansas City, Mo.; H. C. Don Carlos, Toronto, Ont.; F. C. Hanker, East Pittsburgh, Pa.; A. M. MacCutcheon, Cleveland, Ohio; E. B. Meyer, Newark, N. J.; C. E. Stephens, New York, N. Y.; National Secretary F. L. Hutchinson, New York, N. Y. Also present, by invitation: Past-President Charles F. Scott, New Haven, Conn.; Officers-elect: Harold B. Smith, Worcester, Mass.; W. S. Rodman, Charlottesville, Va.; W. S. Lee, Charlottee, N. C.; J. E. Kearns, Chicago, Ill.; Assistant National Secretary H. H. Henline, New York, N. Y.

The minutes of the Directors meeting of May 22, 1929, were approved as previously circulated.

A report of a meeting of the Board of Examiners held June 19 was presented and the action taken at that meeting were approved. Upon the recommendation of the Board of Examiners, the following actions were taken upon pending applications: 147 Students were enrolled; 195 applicants were elected to the grade of Associate; 19 applicants were elected to the grade of Member; 74 applicants were transferred to the grade of Member; five applicants were transferred to the grade of Fellow.

Approval by the Finance Committee for payment of monthly bills amounting to $50,759.51 was ratified.

The following were exempted from future payment of dues as "Members for Life," in accordance with Sec. 22 of the Constitution: F. F. Barbour, E. A. Barnes, W. H. Brenner, H. F. Parshall, L. A. Phillips, Norman N. Ross, George F. Sever, A. E. Worswick.

Approval was given to the date, May 7-10, 1930, selected by the District Executive Committee, for the already authorized meeting in the North Eastern District to be held at Springfield, Mass.

Upon the recommendation of the Chairman of the Sections Committee, the Board acted favorably on a request of the Oklahoma Section and authorized a change in name of that Section to "Oklahoma City Section," and authorized a new Section, comprising the entire state of Iowa, to be known as the "Iowa Section."

Approval was given to the organization of a Student Branch of the Institute at the Michigan College of Mining and Technology, Houghton, Mich., which was recommended by the Committee on Student Branches.

The following were elected Honorary Members of the Institute: Herbert Hoover, Charles F. Brush, (posthumously), and Charles F. Scott.

The following minute in memory of Charles F. Brush was adopted:

On June 15, 1929, through the death of Charles Francis Brush, there was removed from the ranks of the Institute, one of its charter members. Over a period of almost seventy years of activity his name has ever been in the forefront as a pioneer in electrical development work. One of the first to realize the value of the work of Gramme, in 1876 he designed and built a dynamo. In 1878 he exhibited the first of the world famous Brush arc light machines. Scientist, engineer, humanitarian and philanthropist, recipient of world wide honors, Edison Medalist—the Board of Directors of the American Institute of Electrical Engineers wishes to have it recorded that as a mark of appreciation of his services to the profession, Doctor Brush was, at the time of his death, though in accordance with proceedings instituted months before, about to be awarded Honorary Membership, and record of election to Honorary Membership by the unanimous vote of all the members of the Board of Directors is hereby made. Further, the Board of Directors extends to his family and associates its sincere sympathy.

Decision was made to appoint a Local Honorary Secretary of the Institute for Russia, and Doctor Michael Chatelain was appointed for the term of two years beginning August 1, 1929.

A recommendation made at the Conference of Officers and Delegates, June 24, was presented and adopted, that regional meetings hereafter be referred to as "District Meetings." A recommendation made at the same conference that the appropriation year for Sections begin August 1 instead of October 1, was referred to the Finance Committee, with the understanding that if feasible, this change will be put into effect August 1, 1929.

Resolutions were adopted expressing the Board's appreciation of the effective services rendered by the General Convention Committee, its various subcommittees, and the Ladies Committee, in connection with the annual Summer Convention, Swampscott, Mass., June 24-28.

Other matters were discussed, reference to which may be found in this and future issues of the Journal.

The meeting closed with an expression by President Schuchardt of his appreciation of his exceedingly pleasant association with the members of the Board during his administration, and a unanimous vote of appreciation of the members of the Board of the valuable services rendered to the Institute during the past year by President Schuchardt.

Honorary Members Elected

Three distinguished American Engineers were elected Honorary Members of the American Institute of Electrical Engineers at a meeting of its Board of Directors held June 25 during the Annual Summer Convention of the Institute in Swampscott, Massachusetts.

The men thus honored were:

Herbert Hoover, most outstanding American engineer.

Charles F. Scott, engineer and inventor, head of the Electrical Engineering Department of Yale University, Past-President of the Institute.

Charles F. Brush, Cleveland, Ohio, engineer and scientist, recipient of Edison Medal, whose death occurred on June 15, at which time he was being balloted upon. The unanimous vote of the Directors of the Institute having been received, the Directors voted on June 25 to record Doctor Brush's name in the list of Honorary Members.

Five other Americans and three representatives of foreign countries had previously been elected as Honorary Members of the Institute. The Americans are John J. Carty, Thomas A. Edison, Michael I. Pupin, Ambrose Swasey, and Elihu Thomson.

Section and Branch Activities

President Smith in his message on the front page of this issue of the Journal places much emphasis upon the importance of the third object of the Institute, *i. e.*, "the development of th individual engineer" and the functions of the Sections and Branches in carrying the Institute life with its opportunities for active service to the profession to within a reasonable radius of the individual wherever he may be located.

In accordance with this policy of carrying the life and support of the Institute to the individual, as outlined in his message, President Smith is attempting a personal appearance and talk before the membership of each of the fifty-six Sections of the Institute this year. It is hoped that, wherever possible, each of the 101 Branches may unite with the appropriate and nearest Section for these meetings, as these talks are designed especially for the younger membership of the Institute.

The Annual Report on Section and Branch Activities, issued in pamphlet form in June and mentioned in his message, contains an extended resume in summary and statistical form of their principal activities during the fiscal year ending April 30, 1929. The information presented makes clear the facts that the activi-

ties of many Sections and Branches have been greatly improved and that there is deep interest among the officers of the local groups in finding methods which will offer the greatest benefits to the individual members. A considerable amount of space is devoted to cooperation between Sections and Branches. Copies of this Report may be secured without charge upon application to Institute headquarters.

In order to indicate briefly the rapid increase in Section and Branch activities during the past few years, a table which appeared in the Annual Report of the Board of Directors for the fiscal year ending April 30, 1929, is reproduced below.

	For Fiscal Year Ending			
	April 30 1923	April 30 1925	April 30 1927	April 30 1929
SECTIONS				
Number of Sections	46	49	52	54
Number of Section meetings held	344	386	431	460
Total Attendance	46,672	49,029	60,708	73,254
BRANCHES				
Number of Branches	68	82	95	100
Number of Branch meetings held	503	548	842	940
Total Attendance	26,893	27,603	42,650	47,408

Lamme Medal Presentation

The first (1928) Lamme Medal which was awarded to Allan B. Field, as reported in the February 1929 issue of the JOURNAL, was presented to him during appropriate ceremonies at the banquet meeting held on Wednesday evening, June 26, at the Summer Convention at Swampscott. This award was made for "the mathematical and experimental investigation of eddy-current losses in large slot-wound conductors in electrical machinery."

Past-President Charles F. Scott, Chairman of the Lamme Medal Committee, conducted the program during which the presentation was made, and in his opening address spoke briefly upon the significance of the Medal and the characteristics of Benjamin G. Lamme, the founder. A sketch of the career of Mr. Lamme was given by N. W. Storer, who was closely associated with him for many years, and the achievements of the recipient were summarized by B. A. Behrend, with whom Mr. Field was associated at the time he did the work for which the award was made.

Following the presentation of the Medal and a certificate by President Schuchardt, Mr. Field responded with a short address.

At the conclusion of the Lamme Medal presentation program, Professor Scott announced that by a remarkable coincidence, another medal had been awarded to Mr. Field for the same achievement, and the John Scott Medal, awarded by the Board of City Trusts of Philadelphia, accompanied by a check for $1000 and a certificate, was presented to him by F. L. Hutchinson, National Secretary. Mr. Field responded briefly.

Kelvin Medal Awarded to Andre Blondel

At a meeting of the Kelvin Medal Award Committee held in London on the 21st of June, the fourth triennial Kelvin Medal was awarded to Monsieur André Blondel, Membre de l'Académie des Sciences, Membre de l'Institute de France, Officier de la legion d'Honneur, President d'Honneur de la Societe Francaise des Electriciens, Inspecteur General des Ponts et Chaussees, and Honorary Member of the American Institute of Electrical Engineers—he, being in the opinion of the Committee, after consideration of the representations received from leading engineering bodies in all parts of the world, the most worthy to receive on the present occasion this mark of distinction in engineering work and investigation of the kinds with which Lord Kelvin was especially identified.

Colloquium on Power Circuit Analysis

HELD AT MASSACHUSETTS INSTITUTE OF TECHNOLOGY

A colloquium on Power Circuit Analysis with Particular Reference to the Behavior of Machinery and Transmission-Line Stability, was in session at the M. I. T. from June 10 to June 22, 1929. A committee was established to formulate conclusions and recommendations, if possible, and to make suggestions regarding further investigations which might be desirable.

At the final session the report of the committee, with certain modifications, was accepted and some of the items of the report were released for publication in the technical press in the belief that they would be of service to the electrical engineering profession at large.

The colloquium was attended by about 80 representatives of prominent electrical manufacturers, constructing and engineering organizations, electric light and power companies, and technical educational institutions. The conclusions made public are as follows:

CONCLUSIONS AND SUGGESTIONS OF THE COLLOQUIUM

Method of analysis. It is sometimes expedient to assume constant impedances, similarity of direct and quadrature axes, constant linkages, and constant shaft torque. If this be done, and if there are only a few important machines or stations involved, steady-state stability analyses may be made by very simple analytic methods or by the method of mechanical equivalents. Transient analyses involving two machines may be very simply made by the equal-area method. If there are more than two machines the step-by-step method is still relatively simple as a result of these assumptions. The method of mechanical equivalents is also available here. These methods have been described in the literature and will in many cases give accuracies comparable with the accuracy of the data involved and the importance of the matter under consideration. When more accurate or more complete methods are necessary the following are available:

I. Steady State.
 The chart method with or without the help of the network analyzer.

II. Transient State.
 1. Step-by-step method.
  (a) Analytical.
  (b) Aided by the circle diagram.
  (c) Aided by the network analyzer.
 2. Integraph method.
  The integraph is especially suitable for the detailed investigation of the effect of variations in particular machine characteristics; for example, the determination of the effect of excitation systems, amortisseur windings, and the duration of fault.

In any of these methods unbalanced conditions may be reduced to balanced equivalent circuits by the method of symmetrical components.

It is to be emphasized that the results of any method of analysis can be no more accurate than the original data used.

Definitions. The need for a better-established terminology for use in stability studies is recognized, and it is felt that the following steps to establish this terminology are desirable:

(a) It is recommended that the manufacturers of equipment initiate a move for making uniform and definite the terms used in specifying such quantities as exciter response, the reactances of machines, the inertia constant, time constants, damping torque, and reluctance torque.

(b) It is recommended that a communication be addressed to the proper committees of the American Institute of Electrical Engineers and of the National Electric Light Association, stating the need for explicit definitions of certain terms used in stability studies such as static-sta-

bility limit, transient-stability limit, and dynamic or artificial stability.

Further Investigations. The discussion of this colloquium has brought out the need for further analysis and experimentation along many lines, and the following specific lines of investigation and publication of results are recommended:

(a) A study of the effects of saturation in synchronous machines during transient conditions.

(b) Further information in regard to the performance of turbine governors under transient conditions.

(c) Further study of the conditions causing hunting in systems.

(d) Transient power limit tests on life-sized or actual systems and machines for determining the effects of important characteristics such as regulator characteristics, exciter speeds, constants of the amortisseur windings, and breaker time.

(e) Further information in regard to the characteristics of actual loads. This requires the development of methods of determining load characteristics.

(f) Further tests and the development of methods of calculating the impedance of circuits which include ground return.

(g) Further study of the value of different methods of system grounding from the standpoint of system stability.

(h) More complete and accurate records of system troubles, with all necessary data, including such as are obtained by automatic recording oscillographs.

(i) An investigation of the economic value of modifying generator reactance.

(j) Studies explaining the region of applicability and the relative accuracy of the various methods of analysis.

Journal of Engineering Science. The colloquium membership wishes to state that it feels the need for a new journal of engineering science in which material of a highly technical character, such as that listed under the heading, "Further Investigations," can be published more fully than is possible with existing journals.

PERSONAL MENTION

G. B. Pulham, Chief Erecting Engineer for India, Burma, and Ceylon for Metropolitan Vickers Electrical Co., Ltd., returns to Calcutta from England this month.

Justin J. McCarthy has been appointed Sales Engineer of the Sheffler-Gross Company, Inc., 203-11 Drexel Building, Philadelphia, sales agents for heating, ventilating, and power plant equipment.

W. H. Kretz has been appointed to the Transformer Sales Division of the Wagner Electric Corporation, St. Louis. He was formerly Texas district representative for the Jeffery-De Witt Insulator Company.

Harold B. Smith, President of the Institute and professor of Electrical Engineering at Worcester Polytechnic Institute, had two honorary degrees of Doctor of Engineering conferred upon him in June of this year by Purdue University and the Worcester Polytechnic Institute.

Lester R. Sellers, who for nearly three years has been in the mploy of the Station Engineering Department of the Philadelphia Electric Company, Philadelphia, Pa., has now engaged with the Western Electric Company in the Plant Engineering Department of its Hawthorne Station.

R. Harland Horton has been appointed ExecutiveDirector of the Philadelphia Business Progress movement which has been organized to operate for three years. Mr. Horton was previously Vice-President of Operations for the Mitten Management. More than $1,350,000 will be expended in the new development.

J. Verling Walrod, who has been Assistant to the Chief Engineer of the Minneapolis-Honeywell Regulator Company, Minneapolis, Minn. has now joined the Research and Engineering Department of the Time-O-Stat Controls Company, Elkhart, Indiana, in connection with inspection, testing and development work upon new and contemplated products.

E. P. Dillon has been appointed Vice-President and Associate Engineer of the E. Y. Sayer Engineering Corporation, Knickerbocker Building, New York, designers and builders of power and industrial plants. For the past ten years Mr. Dillon has been General Manager for the Research Corporation of New York, in charge of sales of the Cottrell processes of electrical precipitation. He joined the Institute in 1902.

A. R. Robison, who has been Construction Superintendent for the United Gas and Improvement Company, Philadelphia, has been elected Vice-President and General Manager of the Toledo, Bowling Green & Southern Traction Power Company, Findlay, Ohio; the North Baltimore Service Company; the Rudolph Light & Power Company, and the Wooster Electric Company;—all in Ohio. These companies are a part of the Empire Public Service Company's system. Mr. Robison has also been elected to the same office with the Western Ohio Railway & Power Corporation.

Obituary

William Symes Andrews, who for over fifty years has been a representative figure in the electrical world and a man to whom Thomas A. Edison perhaps owes more than to anyone else in the development of the incandescent lamp, died at his home in Schenectady, July 1, 1929. He was but seven months younger than Mr. Edison, and his half-century period of service with him, in Mr. Edison's own words, was fraught "with many pleasant recollections, great interest, and satisfaction."

Mr. Andrews was born in Saltford, England, the son of Bailey and Selina (Chesterton) Andrews. He attended Cuzner's Collegiate Academy at Beckington, near Bath, where he evidenced great aptitude in electrical and scientific matters. After graduation, he was made an instructor in the academy, and so thorough was his knowledge in the scientific field that when only 18 years of age, he became head master of the school, a position which he held for ten years.

In 1875 he removed to Toronto to enter the firm of Raybon & Company, manufacturers of firearms and sporting goods. Two years later, he established a branch factory for the firm in Newark, New Jersey, he himself becoming superintendent. In November 1879 he joined Mr. Edison at Menlo Park in his development of the invention of the incandescent lamp. He assisted in winding the armature of Edison's first dynamo, constructed the first Edison chemical electric meter, molds for carbonizing the filaments of the lamps, and ultimately, the diminutive and delicate mechanisms for picking up the hair-like filaments and placing it between platinum clamps for mounting. Early in 1881, Mr. Edison conducted a test on 600 of his electric lamps, upon which tests depended the decision for their commercial efficiency. It was made Mr. Andrew's responsibility to scrutinize the performance of certain test control apparatus and to regulate it as required. In his ardor over the situation, he worked fifty hours without sleep. On October 8 of that year he was made Superintendent of the Testing Department at the Edison Machine Works, Newark. Two years later in June he became Chief Electrical Engineer of the Central Station Construction Department of the Edison Electric Light Company, during the next three years establishing over thirty local Edison generating stations including those at Sunbury, Pennsylvania—the first Edison three-wire station in the United States; Rochester, New York; Des Moines, Minneapolis, New Orleans, and Chicago. In 1894, Mr. Andrews went to Schenectady to enter the employ of the General Electric Company, and from 1897 to 1903 he was engaged in X-ray testing, taking out a number of patents on methods of testing and regu-

lating X-ray tubes. In fact, it is undoubtedly true that he died a martyr to scientific development due to the effects of X-ray burns sustained over a prolonged period of thirty-five years' investigation, at a time when, because of its comparative infancy, the whole danger of the properties of X-ray was not understood. The subject of illumination by phosphorescence and fluorescence was also of great interest to him. In 1913 he was made Consulting Engineer for the company, a post he held at the time of his death.

When in the Spring of 1922 active steps were taken to gather and preserve the relics of early Edison days, now forming our Historical Electrical Collection, it was Mr. Andrews who responded at once to the call, and through the kindness of the General Electric Company, was permitted to devote a great deal of his time to aiding, and giving all the benefit of his experience.

Mr. Andrews became an Associate of the Institute in 1889; he was elected a Fellow in 1912, and was made a Member for Life October 1926. He was a Fellow also of the Illuminating Engineering Society, a Member of the American Association for the Advancement of Science, the National Electric Light Association, the Franklin Institute of Philadelphia, the Historical Society of Pennsylvania, and the Edison Pioneers. F. A. Wardlaw, Secretary of the Edison Pioneers, in his tribute to Mr. Andrews says, "Endeared as he was to scientists and technicians for his many contributions to theory and practise, he was equally endeared to all whose privilege it was to really know him, as a man of lovable character, and sterling integrity, seeing the good, and only good, in every situation by which he was confronted. The superlative spartanism which he exhibited throughout his years of illness,—in fact throughout his entire life,—will long remain a cherished memory."

Eugene H. Abadie, Consulting Engineer, Washington, D. C., and prominent in the profession for a great many years, was killed at the wheel of his automobile in collision with a telegraph pole April 27. On his way to his golf club, he swerved his car to escape another which had swung from the curb, and in the suddenness of the action he lost control of the car and it crashed, injuring him so vitally that he died on the way to the hospital.

Colonel Abadie was a Life Member of the Institute, which he joined in 1905. He was a native of St. Louis, Missouri, where, after finishing high school, he was graduated from the St. Louis Manual Training School. He entered Washington University, but did not graduate, leaving to accept an attractive offer made him by Herbert A. Wagner to join him in building up a company just then incorporated—the Wagner Electric Mfg. Company.

For a period of six months Mr. Abadie worked in the shops; later he divided his time between the shops and the office. The latter part of 1892 he was given the active management of the Company's business with the title of Manager of Sales. Continuing in this capacity until 1900, he formed an organization for the control of the output of the Bullock Electric Mfg. Co. and the Wagner Electric Company. He was immediately chosen Manager and the following year he was one of the incorporators of the Wagner Bullock Electric Company of California, which during its first year he served in the capacity of Vice-President. In 1902 he established his own company under a partnership name of E. H. Abadie & Company, for general engineering and contract work of which there was a superabundance at that time in the Middle-Western and Southwestern states. For a while he was affiliated with the Elblight Company of America, in an effort to reorganize. When he removed from St. Louis to Washington, D. C., he established a consulting engineering office of his own, with which he was occupied at the time of his death.

Mr. Abadie joined the Institute in 1905 as an Associate and was transferred to Member in 1913. He was a Director as well as a Charter Member of the American Society of Engineering Contractors; a Member of the Engineers' Club of St. Louis; a Member of the League of Electric Interests of St. Louis and of the Jovian Order.

William O. Winston, Jr., Vice-President and Director of the Winston Brothers Company, Minneapolis, and an Associate of the Institute since 1915, died at the age of 43, June 18 on the Pacific Coast, after a short illness.

Mr. Winston was a student in Electrical Engineering at Cornell University from 1908 to 1911, when he became foreman of the ore mine work of the Winston Brothers Company at Hibbing, Minn. The following year he went to Hersey, Wisconsin, as the agent of that company there and at Great Falls, Montana, later to be given charge of small lighting plants used in construction work at Malta, Mont. In 1914 he removed to Junction, Colo. At the time of his death he was in charge of Grand construction of the Diablo Dam on the Skagit River, a unit in the hydroelectric development for the city of Seattle.

Thomas Edward Murray, who for many years was in charge of all the allied Edison companies in New York and Brooklyn, and subsidiaries in Westchester County, and to whom, next to Thomas A. Edison, have been granted more patents than to any other inventor in the United States died the morning of July 21 at his summer home, Wickapogue, Southampton, after an illness which has extended over several months.

Mr. Murray was sixty-nine years old. He was born at Albany, New York, and attended the public and private night schools there for nine years, for two years doing additional work in the drafting room of local architects and engineers. For four more years, he served an apprenticeship as machinist in the shops of the Albany Iron & Machine Works. In 1881 he entered the employ of the Albany Water Works as Operating Engineer, remaining in that capacity until 1887, when he became Chief Engineer, Superintendent and then General Manager for the Albany Electrical Illuminating Co. From 1890 to 1900, he was Consulting Engineer for the Albany Railway Co., the Troy City Railway Company, the Troy Electirc Light Company and the United Traction Company (Albany and Troy); and from 1899 he was Consulting Engineer for the Kings County Electric Light & Power Company and the Brooklyn Edison. He was also General Manager of the New York Gas and Electric Light, Heat, and Power Company from its incorporation date.

At an early age he established a reputation as an expert machinist and attracted the attention of the late Anthony N. Brady, who was then entering the field of public utilities. Mr. Murray was placed in charge of the Municipal Gas Company of Albany, and while holding that post his inventive genius, which was to yield him a record of over 1100 patents, began to assert itself. While he was still very young, Mr. Brady sent him to New York to organize and purchase all electric franchises in New York and Brooklyn. This resulted in the Edison Electric Illuminating Company of Brooklyn, which afterward was called the Brooklyn Edison Company, Inc. His work in New York led to the formulation of the New York Edison Company and the United Light and Electric Light Company. Upon consolidation of these interests, Mr. Murray was placed in complete charge of all allied Edison Companies, as well as the outlying subsidiaries. Last year, because of ill health, he was forced to resign from the vice-chairmanship of the Board of the New York Edison Company, but he continued to maintain a general supervision of his own corporations, the Metropolitan Engineering Company, the Metropolitan Device Corporation, the Murray Radiator Company and Thomas E. Murray, Inc. He was also a Past-President of the Association of Illuminating Companies.

Notwithstanding the fact that most of his earlier work was in the electrical and gas appliance fields, the force of his activities has been felt in almost every phase of modern industry. For innumerable inventions of safety applicances, he has received the Lonstreth Medal from the Franklin Institute of Philadelphia; during the World War, his method of welding shells was productive of the 240-mm. mortar shell, winning him high commendation from the War Department. In his consulting engineering work he redesigned and directed the mechanical and electrical construction of the Troy Electric Light Company's plant the Troy

City Railway's plant, including rotary substations of the United Traction Company, and designed and directed the construction of the Kings County Electric Light & Power Company's station in Brooklyn. Mr. Murray joined the Institute in 1901 and became a Fellow in 1912. He was also a prominent member of the American Society of Mechanical Engineers.

Ferntagung Meeting By Long Distance Telephone

The electrical industry was well represented at the thirty-fourth Annual Meeting of the Verband Deutcher Elektrotechniker at Aachen, Germany, July 8-9, 1929. Electrical societies of Germany, Holland, Austria, and Hungary participated in sessions held jointly by means of telephonic communication, and the feasibility of holding future joint meetings by telephone was clearly demonstrated.

The address of welcome was given by General Director Doctor E. M. Krone, of Dortmund, who, after greeting his guests and those in other countries taking part in the proceedings gave a forceful talk on the advancement made in the electrical industry during the past year. He was followed by E. L. P. Craemer, who discussed international long distance telephony. Short addresses followed by Professor Dr. Reithoffer, Electrotechnical Society, Vienna, Director Beekman, of the Royal Holland Institute, Division of Electrotechnik, in Hague, Holland, and last, Professor Carl Zipernowsky, of the Hungarian Electrotechnical Society, Budapest. Other speakers from the Hague, Vienna, and Budapest also spoke from their respective cities by telephone. The meeting closed Tuesday evening with a garden party.

A. I. E. E. Section Activities

SECTION ORGANIZED AT BIRMINGHAM, ALABAMA

At a meeting held in Birmingham on June 21, the Birmingham Section, which had been authorized by the Board of Directors on May 22nd, was organized. R. W. Lamar, Chief Engineer of the Birmingham Electric Company, was elected Chairman, and O. E. Charlton of the Engineering Department, Alabama Power Company, was chosen as Secretary.

Vice-President C. O. Bickelhaupt of the Southern District was represented at the meeting by S. A. Flemister. H. L. Wills, Chairman of the Atlanta Section, was present and gave a brief talk on the activities of the Institute. H. M. Woodward was elected Delegate of the Section to the Summer Convention at Swampscott, Mass.

PAST SECTION MEETINGS

Akron

The Engineers' Participation in Civic Affairs, by R. F. Schuchardt, President, A. I. E. E. Short addresses by L. G. Tighe, Ass't General Mgr., Northern Ohio Power & Light Co.; Henry Vance, Local Consulting Engr.; A. O. Austin, Chief Engr., Ohio Insulator Co., and W. A. Hillebrand, Chairman-Elect of the Section. Annual Meeting, joint with University of Akron Branch. Talk by C. D. Tinley, Chairman of the Branch. The following officers were elected for next year; Chairman, W. A. Hillebrand; Secretary, R. R. Krammes; Treasurer, N. Berthold; Chairman, Meetings & Papers Committee, H. C. Paiste; Chairman, Membership Committee, W. J. Secrest. May 24. Attendance 58.

Cincinnati

Engineers and Their Perspective, by W. E. Stilwell, Jr., and *Imprint of Engineering on Industry*, by Retiring Chairman R. C. Fryer. Brief talks by Ted Hubbell, Embry-Riddle Co., on "Engineers and Aviation;" G. L. Tarrington, Electrical Research Products, Inc., on "Talking Movies," and Dr. B. A. Schwartz, Heart Specialist, on "The Electric Cardiograph." Secretary-Treasurer gave his annual report. Officers elected for next year are as follows: Chairman, T. C. Reed; Secretary-Treasurer, L. L. Bosch; Directors, L. O. Dorfman, E. S. Fields, W. E. Beatty, J. A. Noertker and H. D. Rei. Dinner guests at the Maketewah Country Club on invitation of Francis R. Healy. June 13. Attendance 53.

Detroit-Ann Arbor

Research on Wind Loading of Electrical Power Lines (in two parts): *Fundamental Theory and General Methods*, by Prof. R. H. Sherlock, University of Michigan, and *Development of the Electrical Recording Meters*, by Asst. Prof. M. B. Stout, University of Michigan. Slides. Large amount of interest shown in the discussion. Report on plans for annual outing on June 18, appointment of teller's committee, and discussion of committee appointments for next year. May 21. Attendance 150.

Annual Outing of the Section at Edison Boat Club. Officers for next year were announced as follows: Chairman, L. F. Hickernell; Vice-Chairman, LeRoy Braisted; Secretary-Treasurer, T. N. Lacy. June 18. Attendance 110.

Erie

Power Company Development and Industrial Progress, by T. F. Barton, District Engr., General Electric Co., New York, Vice-President J. L. Beaver gave talk on the work of the Institute. Officers for next year are as follows: Chairman, W. H. Pelton; Secretary, G. I. LeBaron; Executive Committee, W. H. Reynolds, M. V. Wright and H. B. Joyce. June 11. Attendance 80.

Niagara Frontier

Construction of the Cascade Tunnel on the Great Northern Railway, by J. B. Cox, Railway Engg. Dept., General Electric Co., Schenectady. Film—"Driving the Longest Railroad Tunnel in the Western Hemisphere." Reports of Membership Committee and Treasurer. The Chairman appointed an Auditing Committee. The proposed "Agreement for the joint use of club rooms, meeting rooms, secretarial services and other facilities of the Engineering Society of Buffalo, Inc., by the Niagara Frontier Section" was unanimously adopted. The Chairman turned over to the Membership Committee a list of enrolled Students in western New York, with the request that the committee get into personal touch with a view to securing their active participation. Election of officers as follows: Chairman, R. T. Henry; Secretary-Treasurer, E. P. Harder; Executive Committee, R. W. Graham, R. L. Kimber. George W. Eighmy, General Electric Co., Buffalo, was appointed Assistant Secretary by the Chairman. The speaker was entertained at a dinner preceding the meeting. May 24. Attendance 105.

Philadelphia

Illumination of the Mastbaum Theatre, by J. F. Costello, Frank Adam Electric Co., and

Ventilation, Mechanical Equipment and General Construction of the Mastbaum Theatre, by C. S. Dingleman, Consulting Engr. The papers were followed by an inspection of the electrical and mechanical equipment of the Mastbaum Theatre. Election of officers for next year as follows: Chairman, R. H. Silbert; Secretary, J. L. MacBurney; Treasurer, E. C. Drew. Joint meeting with Philadelphia Section, Illuminating Engineering Society, and Electric Club of Philadelphia. June 10. Attendance 465.

Spokane

Annual Dinner Meeting. Chairman Olsen gave a brief address regarding the activities of the past year. Reports of several committees presented. The following officers were elected for next year: Chairman, Earl Baughn; Vice-Chairman, James B. Fisken; Secretary, C. B. Carpenter; Executive Committee, W M. Allen, L. R. Gamble and H. L. Vincent. May 24. Attendance 15.

Lecture and Demonstration of modern electrical marvels and inventions pertaining to sound transmission, by S. P. Grace, Ass't Vice-President, Bell Telephone Laboratories, Inc. June 11. Attendance 1850.

A I E E Student Activities

PAST BRANCH MEETINGS

Brooklyn Polytechnic Institute

Business Meeting. Election of officers. May 24. Attendance 40.

University of Detroit

Annual Banquet. Speakers: N. S. Diamant, Research Engr., Chrysler Corp.; Dr. T. Leucutia, Radiological Dept., Harper Hospital; W. A. Furst, Mgr. Engineering Dept., Westinghouse Electric & Mfg. Co., Detroit. C. W. Hungerford, Advertising Mgr., Michigan Bell Telephone Co.; R. Foulfrod, Plant Extension Eng., Michigan Bell Telephone Co., and E. E. Walerych, Supt. of Maintenance, Plymouth Plant, Chrysler Corp. June 6. Attendance 100.

University of Idaho

Business Meeting. Election of officers. May 24. Attendance 30.

School of Engineering of Milwaukee

Copper, by Dr. Koch, Head of Chemistry Dept. Film—"From Mine to Consumer—The Story of Anaconda." Election of officers for next year as follows: Chairman, T. J. Coleman, Jr.; Vice-Chairman, W. L. Haegquist; Secretary, K. O. Werwath; Treasurer, C. H. Skinner. January 5. Attendance 46.

University of Minnesota

Business Meeting. Election of officers. May 24.

Student Work in A. I. E. E. Branches, by Prof. J. H. Kuhlmann, Counselor;

Relation of A. I. E. E. Branch to Department of Electrical Engineering, by Prof. J. M. Bryant, Head of Dept.;

Relation of A. I. E. E. Section to Branch Work, by Prof. M. E. Tood, Chairman, Minnesota Section, and

The Young Electrical Student and the A. I. E. E., by Prof. E. W. Johnson. Annual banquet, held largely to create more interest and enthusiasm in the work of the Branch, Prof. W. T. Ryan, toastmaster. May 29. Attendance 57.

University of Idaho

Business Meeting. May 7.

Pennsylvania State College

New York's City Subways, by Mr. Heine. Film—"Building New York's Newest Subway." Joint meeting with the Metallurgical Society. March 13. Attendance 26.

Life in Porto Rico, by Manual Andjuar. April 10. Attendance 20.

Jewelled Bearing Manufacture, by B. W. St. Clair, Head of the Standards Laboratory, Lynn Works, General Electric Co. Slides and specimens. President-elect W. Mason gave a report on the Cincinnati Regional Meeting. May 1. Attendance 30.

University of Wisconsin

Business Meeting. Election of officers. May 28. Attendance 23.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these Founder Societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES, JUNE 1-30, 1929

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

Arc Welding; Lincoln Prize Papers submitted to the American Society of Mechanical Engineers. Edited by Edward P. Hulse. N. Y., McGraw-Hill Book Co., 1929. 421 pp., illus., diagrs., tables, 9 x 6 in., cloth. $5.00.

The Lincoln Arc Welding Prizes were given by the Lincoln Electric Company to be awarded by the American Society of Mechanical Engineers for the three best papers on arc welding. The seven papers published in this book include the three prize winners, the two that received honorable mention and two others of unusual merit.

The papers are "Arc Welding—Its Fundamentals and Economics" by James W. Owens, "Fundamental Principles of Arc Welding" by Prof. H. Dustin, "Electric Welding of Ships, Bulkheads and Similar Plated Structures" by Commander H. E. Russell. "Theory and Application of the Base Plate Arc Welded Rail Joint" by Frank B. Walker, "Stable Arc Welding on Long-Distance Pipe Lines" by B. K. Smith, "Arc Welding as Applied to Construction Work at the Philadelphia Navy Yard" by M. W. Kennedy and F. H. Wieland, and "Arc Welding of Duplicate Steel Structures" by W. H. Himes.

Bases of Modern Science.

By J. W. N. Sullivan. Garden City, N. Y., Doubleday, Doran & Co., 1929. 274 pp., 8 x 5 in., cloth. $2.00.

An admirable history of the growth and development of physical science from the time of Copernicus to the present day. Mathematical formulas are conspicuously absent, the treatment is as simple as the subject permits, and the book traces very satisfactorily the rise and decline of the conceptions which have dominated physics from time to time.

Berichte Uber Betriebswissenschaftliche Arbeiten, bd. 1 & bd. 2. Berlin, V. D. I. Verlag, 1929. 63 pp. & 51 pp., illus., diagrs., 12 x 9 in., paper. 11.-r. m. each.

The first two issues of a new serial devoted to the publication of complete reports of interesting investigations of processes and machinery which, for lack of space, cannot be given fully in ordinary periodicals. Each of these issues contains three reports from the laboratory of the Dresden Technical High School. The first, on woodworking machinery, treats of planing, mortising and working veneers. The second, on metal working processes, discusses the drawing of hollow vessels from thin sheets, the efficiency of machine hacksaws, and broaching.

Berichtfolge des Kohlenstaubausschusses des Reichskohlenrates, 18th & 19th, April & June 1929. Berlin, V. D. I. Verlag, 1929. 16 pp. & 12 pp., 12 x 8 in., paper. 1 r. m. each.

The papers in these two reports of the Committee on Pulverized Coal discuss various questions of interest to users; facts for buyers, ignition and combustion phenomena at various furnace pressures, heat flow and storage in furnace walls; the behavior of ash; the possibility of separating ash from flue gases; conveying pulverized coal; and the extinguishing of pulverized coal fires.

Business Law for Engineers.

By C. Frank Allen. 3rd edition. N. Y., McGraw-Hill Book Co., 1929. Various paging, 9 x 6 in., cloth. $4.00.

This text aims "to give the engineer a sufficient understanding of important fundamental features of law, so that he may have some idea of when or how to act himself and when to seek expert advice." The author has had experience both as an attorney and as a civil engineer.

In this edition there is a new chapter on "cost plus" contracts, and several new forms of contracts.

Diagramme und Tabellen Zur Berechnung der Absorptions -Kältemaschinen.

By Fr. Merkel and Fr. Bosnjakovic. Berlin, Julius Springer, 1929. 43 pp., diagrs., tables, 11 x 8 in., paper. 12.-r. m.

The simple formulas and graphical tables, which the authors have prepared from recent investigations, simplify greatly the design of absorption refrigerating machines. The necessary data and tables are given here, with a description of their use.

Electrical Transmission and Distribution . . . v. 5-6; Substation Work, pt. 1 & pt. 2. Edited by R. O. Kapp. N. Y., Isaac Pitman & Sons, 1929. 2 v., illus., diagrs., tables, 8 x 5 in., cloth. $1.75 each.

Volumes five and six of this treatise on transmission and distribution treat of substations. Transformer construction and operation; converting machinery; mercury vapor rectifiers; the design, layout, testing and operation of a-c. substations; and automatic substations are considered. Each section is the work of one or more English specialists. The work is intended as a practical guide for those engaged in transmission work as builders or operators of transmission systems.

Electrical Transmission and Distribution, v. 7-8; v. 7, Instruments and Meters. v. 8, Auxiliary Plant. Edited by R. O. Kapp. N. Y., Isaac Pitman & Sons, 1929. 2 v., illus., diagrs., 8 x 5 in., cloth. $1.75 each.

These two volumes complete the work. Volume 7 contains data on ammeters, voltmeters, ohmmeters, wattmeters, instrument transformers, electricity meters, the operation of meter departments, and control room design. Volume 8 discusses boosting devices and the power-factor problem, and contains an appendix on the development of the high-tension circuit breaker which describes recent research work on the breaker and the breaker arc.

Electrification of Steam Railroads.

By Kent Tenney Healy. N. Y., McGraw-Hill Book Co., 1929. 395 pp., illus., diagrs., tables, 9 x 6 in., cloth. $5.00.

Combines a description of the physical characteristics of the elements of electrification with an analysis of economic problems and the operating performance of both electrification and electric operation. Power contracts, overhead systems of distribution and the economics of electrification are given special attention.

English and Science.

By Philip B. McDonald. N. Y., D. Van Nostrand Co., 1929. 192 pp., 9 x 6 in., cloth. $2.00.

Proper forms for formal and informal reports and for letters, the importance of correct language, common faults of poor writers, punctuation, and sentence structure are the subjects to which Professor McDonald devotes the greater part of his textbook. In addition there is much sound advice on minor matters, and interesting suggestions for cultural reading. The book should be helpful in assisting professional men to attain a concise, attractive, clear style.

Die Festigkeit der Schraubenverbindung in Abhängigkeit von der Gewindetoleranz, im Auftrage von Bauer u. Schaurte . . .edited by Kurt Mütze.

Berlin, Julius Springer, 1929. 108 pp., illus., plates, diagrs., tables, 9 x 6 in., cloth. 6,50 r. m.

This investigation of the factors that influence the strength of bolts was carried out at the Dresden Technical High School, at the request of leading German bolt makers. The methods and instruments are described in full, as well as the results obtained.

Festschrift der Technischen Hochschule. Stuttgart . . . 1829-1929. Berlin, Julius Springer, 1929. 475 pp., illus., diagrs., 11 x 8 in., cloth. 24.-r. m.

This attractive volume is issued by the Stuttgart Technical High School in celebration of its centennial. Thirty-seven papers by members of the faculty describe investigations in the various fields—engineering, science and art—in which the school is active.

Genauigkeitsermittlungen an Werkstücken zur Bestimmung Zweckmassiger Passungssitze.

By K. Gramenz. Berlin, V. D. I. Verlag, 1929. 24 pp., illus., diagrs., 12 x 9 in., paper. 3-r. m.

The effectiveness and adaptability to shop practise of the system of fits and tolerances adopted by a factory is the subject under investigation here. The pamphlet describes methods and apparatus for determining the quality of workmanship existing in a factory, and for ascertaining the most economical degree of exactitude to be sought.

Die Grundlagen der Tragflügel—und Luftschraubentheorie.

By H. Glauert. Trans. by H. Holl. Berlin, Julius Springer, 1929. 202 pp., diagrs., tables, 9 x 6 in., paper. 12,75 r. m.

A translation of "The Elements of Aerofoil and Airscrew Theory," with practically no changes from the English edition of 1926. The book presents the theory in a form suitable for students who do not know hydrodynamics, and avoids complex mathematical analysis.

Junkers; Festschrift.

By A. Berson and others. Issued by Verein Deutscher Ingenieure. Berlin, V. D. I. Verlag, 1929. 99 pp., illus., 12 x 9 in., cloth. 6,-r. m.

This attractive volume, prepared to celebrate the seventieth birthday of Hugo Junkers, is a review of the outstanding events of his engineering career by some of his friends. The Junkers oil engine, Junkers' contributions to heat engineering, construction and materials, and his activities in aviation are described by various specialists.

Manual of Engineering Drawing.

By Thomas E. French. 4th edition. N. Y., McGraw-Hill Book Co., 1929. 466 pp., illus., diagrs., tables, 9 x 6 in., cloth. $3.00.

The fourth edition of this popular text has been made to conform to the standards of the American Standards Association, and certain topics, including auxiliary projections, dimensioning, and gears, have been expended. The number of problems has also been increased. The book aims to provide a thorough course based on good engineering practise.

Mechanics for Engineers.

By Leroy W. Clark. Baltimore, Williams & Wilkins, 1928. 192 pp., diagrs., 9 x 6 in., cloth. $3.50.

Simplicity and brevity are emphasized in this textbook based on the author's courses at the Rensselaer Polytechnic Institute. The book aims to give a knowledge of mechanics adequate for the needs of undergraduate students in a very short amount of time, and to provide the necessary foundation for advanced work by graduate students.

Men, Money and Motors.

By Theodore F. MacManus and Norman Beasley. N. Y., Harper & Brothers, 1929. 284 pp., 9 x 6 in., cloth. $3.00.

This is the personal story of the pioneers of the automobile industry. Their early struggles, their failures and successes, are told graphically. It tells how the industry began, how the various companies grew and were consolidated into the present corporations, and of the personal fortunes of the leaders in developing them. An interesting story is told dramatically.

Pastures of Wonder; the Realm of Mathematics and the Realm of Science.

By Cassius Jackson Keyser. N. Y., Columbia University Press, 1929. 208 pp., 8 x 6 in., bound. $2.75.

Professor Keyser's book has a two-fold purpose. He first endeavors to help the intelligent layman to acquire an understanding of the modern meaning of the term Mathematics. In the second part of his book, which discusses the meaning of the term Science, he proposes a definition of Science which will, he believes, remove the ambiguity now associated with the word.

PITMAN'S TECHNICAL DICTIONARY OF ENGINEERING AND INDUSTRIAL SCIENCE IN SEVEN LANGUAGES; English, French, Spanish, Italian, Portugese, Russian and German, vol.1. Compiled by Ernest Slater. N. Y., Isaac Pitman & Sons, 1928. [3v. completed.] v. 1, 582 pp., 10 x 7 in., cloth. $12.50 a vol.

This dictionary will be found invaluable by every translator of English catalogs and technical articles and books into the languages that it covers. Unusual care seems to have been taken to cover the field adequately and to provide accurate equivalents. Special attention has been given to idiomatic phrases, and a useful essay on the art of technical translation is included.

PRACTICAL PRIMARY CELLS.

By A. Mortimer Codd. N. Y., Isaac Pitman & Sons, 1929. 127 pp., illus., diagrs., tables, 8 x 5 in., cloth. $1.50.

Gives working details for the primary cells that have the greatest practical value for laboratory and commercial uses. A list of some two hundred types of cells is included, showing their composition, inventor, and electromotive force.

PROBLEMES DE STATIQUE GRAPHIQUE ET DE RÉSISTANCE DES MATÉRIAUX.

By Louis Roy. Paris, Gauthier-Villars et Co., 1929. 119 pp., diagrs., 9 x 6 in., paper. 30 fr.

A collection of problems derived from examinations at the Institute of Electrical Engineering and Applied Mechanics at Toulouse University and those for certificates in applied mechanics. Intended as a companion to the author's textbook on the same subjects, and similarly arranged.

RADIO TELEGRAPHY AND TELEPHONY.

By Rudolph L. Duncan and Charles E. Drew. N. Y., John Wiley & Sons, 1929. 950 pp., illus., diagrs., tables, 9 x 6 in., cloth. $7.50.

A systematic presentation of the subject in great detail, covering generating and receiving apparatus of all kinds, and discussing both theoretical and practical aspects of radio communication. The authors are experienced teachers, connected with the Radio Institute of America. The book is designed for use as a textbook and work of reference.

RAILWAY ELECTRIFICATION AND TRAFFIC PROBLEMS.

By Philip Burtt. N. Y., Isaac Pitman & Sons, 1929. 197 pp., illus., maps, 9 x 6 in., cloth. $3.00.

A presentation of the general question of electrification from the point of view of a traffic manager. It brings together the pertinent facts from the experience of various countries and discusses the problems involved. The author is an advocate of electrification for main lines.

TASCHENBUCH FÜR BERG—UND HÜTTENLEUTE.

Edited by F. Kögler. 2d edition. Berlin, Wilhelm Ernst & Sohn, 1929. 1207 pp., diagrs., tables, 7 x 5 in., cloth. 33,50 r. m.

This reference book brings together a remarkable amount of the practical data ordinarily needed by the mining engineer and metallurgist. The new edition has been carefully revised and considerably enlarged.

DAS TECHNIKERPROBLEM.

By W. Franz. Berlin, V. D. I. Verlag, 1929. 49 pp., 8 x 6 in., paper. 2,50 r. m.

A discussion of engineering education, particularly of the proper curriculum for training engineers for state and municipal offices. The author outlines courses which include both economic and engineering subjects, corresponding somewhat to the courses in engineering administration offered by some American colleges.

TELEPHONE AND POWER TRANSMISSION.

By R. Bradfield and W. J. John. N. Y., John Wiley & Sons, 1929. 238 pp., diagrs., tables, 9 x 6 in., cloth. $5.75.

A textbook intended for those who approach the subject with a limited knowledge of mathematics. The authors first give an introductory statement on the use of vectors and hyperbolic functions, after which the theory of transmission is presented. The practical application of the theory to the problems of long-distance telephone transmission is then shown, after which the problems of single-phase and three-phase power lines are discussed.

TEXTBOOK OF ILLUMINATION.

By William Kunerth. N. Y., John Wiley & Sons, 1929. 269 pp., diagrs., 9 x 6 in., cloth. $3.00.

A brief text based on the course given by the author to senior electrical students at the Iowa State College. The principles are presented, with enough applications to illustrate them, but without any effort to present all possible forms. The course is thought sufficient to prepare the student for the problems that arise in ordinary practise.

TREATISE ON DIFFERENTIAL EQUATIONS.

By A. R. Forsyth. 6th edition. N. Y. & Lond., Macmillan Co., 1929. 583 pp., 9 x 6 in., cloth. $6.75.

Professor Forsyth's well-known volume is intended as a practical working text-book on the subject, and the general theory has been definitely avoided.

The sixth edition varies from the fourth in minor matters only.

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MEN AVAILABLE.—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to **EMPLOYMENT SERVICE, 31 WEST 39th Street, New York City,** *and should be received prior to the 15th day of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary: temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

See also p. 42 of Advertising Section

POSITIONS OPEN

ELECTRICAL ENGINEER, about 35, with practical experience in general manufacturing of transformers, motors, switchgear; able to diagnose trouble in repairing of apparatus, full knowledge of mechanical tools and winding necessary. All round man required to take charge of plants. Apply by letter stating full details with references and salary expected. Opportunity. Location, Western Canada. X-8608-CS.

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ELECTRICAL ENGINEER, age 31; married; fourteen years direct experience with the design, construction and erection of electrical equipment; also experienced in the design and layout of substations, transmission lines, etc. Desires position with reliable electrical concern who would be able to utilize his services. Canada preferred. C-6149.

ELECTRICAL ENGINEER, 37, married. Nine years' experience with stations, branch of large municipal plant design, estimates, appraisals of large a-c. and d-c. equipment, mechanical, communication work. Good technical,

business training, sales ability. Desires position involving business as much as technical work, with growing concern, good future essential. Now employed; available at short notice. Location, Canada. C-6165.

ELECTRICAL AND MECHANICAL ENGINEER, 31, graduate, seven years' experience with public utility, steel mill, and manufacture; desires new connection in executive capacity involving major responsibilities and requiring alertness, initiative, personality, resourcefulness, and dependability. Thoroughly familiar with both the electrical and steam ends. At present in charge of responsible work. C-1297.

ELECTRICAL-MECHANICAL ENGINEER, 32 years old; 6½ years testing, designing, transmission line research and central station experience, desires position of responsibility with manufacturing or operating company. C-200.

PUBLIC UTILITY OPERATION AND MANAGEMENT, Electrical Engineer with broad experience in public utility design and operation, and in accident prevention applied to public utility design and operation. Experience in investigation and report work. Knowledge of personnel studies. Preferred location, Eastern United States. B-4411.

GRADUATE ELECTRICAL AND MECHANICAL ENGINEER, with two years post graduate work physics. Desires position as research or consulting engineer. 10 years' experience high-tension and automatic devices. Some X-ray work. Will accept position as designing engineer where facilities for research are available. Executive, organizing ability. Location, United States, or abroad. B-9406.

ELECTRICAL ENGINEER, over 20 years' experience, including two years as associate physicist at Bureau of Standards. Last four years full professor of Electrical Engineering in leading technical school. Specialist in theoretical and mathematical analysis of engineering problems; research, design and invention. Broad knowledge of radio. Location preferred South or East. C-6141.

DEVELOPMENT ENGINEER, 15 years' experience with engineering developments. Can take entire charge of a development program. B-208.

ELECTRICAL ENGINEER, year's experience both in hydro and steam in construction and operating. Member A. I. E. E.; married; college education, speaks Spanish, employed in Latin countries for over seven years. Present employed would be available in 30 days. Foreign fields preferred. B-4552.

PIONEER, on a-c. network design; technical graduate with 14 years' experience in the design, construction and operation of public utility properties; desires to make connection with a public utility company or a contracting firm with a view to future partnership. A-4319.

ELECTRICAL ENGINEER. Technically trained, mature judgment, personality, 11 years' experience, large industrial plants such as steel, paper mills; construction, maintenance, repairs, redesigning, rewinding armatures, stators, transformers; design, construction special automatic controls for specific duty. Four years' experience, large custom repair shop. Desires position industrial concern, custom repair shop. Middle West preferred. C-5916.

ELECTRICAL ENGINEER, graduate, desires position with manufacturing concern public utility or contractor, 18 years' experience in the electrical industry, 10 of which, to date, connected with the largest public utility company. Design, construction, maintenance, power houses, substations, distribution, handling materials, specifications, etc. Location, here or abroad. C-6055.

ELECTRICAL ENGINEER, B. S. 1921, one year as inspector and assistant research engineer on cables, seven years electrical designer of substations, power house, oil and copper refineries. Desires position in New York City, or Newark, New Jersey. C-5473.

ASSISTANT EXECUTIVE, 37, married, technically trained. Connections with large public utility, manufacturers and industrial consultants on work of administrative and commercial research nature. Especially qualified as assistant to busy executive needing man with management ability. Well endorsed. Prefers East. B-9122.

ELECTRICAL ENGINEER, having several years' practical experience and executive ability, winding, test and operation of a-c. and d-c. motors, generators; design, controllers, contactors, motors and electrical maintenance in industrial plants and steel mills. C-4128.

INVENTOR, Engineer will originate devices for specific requirements, develop for production. Expert knowledge of patents. Salary basis or otherwise. B-208.

PRODUCTION ENGINEER, 29, single, well trained in electrical and mechanical engineering. Desires permanent connection. Three years before graduation and four years after graduation of diversified engineering experience. Location, anywhere. C-696.

MEMBERSHIP—Applications, Elections, Transfers, Etc.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before August 31, 1929.

Bullen, R. P., General Electric Co., Worcester, Mass.
Coleman, E. S., Dallas Power & Light Co., Dallas, Tex.
Collins, W. G., Pacific Tel. & Tel. Co., San Francisco, Calif.
Cox, A. A., c/o General Electric Co., New York, N. Y.
de Ferranti, M. A., General Electric Co., Schenectady, N. Y.
Early, F. J., Jr., P. J. Walker Co., San Francisco, Calif.
Faigo, M. D., R. C. A. Photophone Inc., New York, N. Y.
Fyfe, L. J. G., Thames Valley Electric Power Board, Te Aroha, Auckland, N. Z.
Gallagher, G. J., Continental-Diamond Fibre Co., Boston, Mass.
Hamby, H. M., Stone & Webster Engg. Corp., Bennings, D. C.
Janes, G. N., Associated Gas & Electric Co., Calais, Me.
Jessop, G. A., (Member), S. Morgan Smith Co., York, Pa.
Kilgore, L. A., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Lott, H. A., Southern California Edison Co., Los Angeles, Calif.
Mapes, L. R., (Member), Illinois Bell Telephone Co., Chicago, Ill.
Meagher, R. J., Rochester Gas & Electric Corp., Rochester, N. Y.
Mulligan, J. E., Mass. Institute of Technology, Cambridge, Mass.
Murray, V. M., School of Engineering of Milwaukee, Milwaukee, Wis.
O'Neil, C. B., Fairbanks, Morse & Co., Houston, Tex.
Prutton, L. J., Cleveland Electric Illuminating Co., Cleveland, Ohio
Schoenborn, F. J. W. F., Radio Corp. of America, Riverhead, N. Y.
Scholten, C. H., Aluminum Good Mfg. Co., Manitowoc, Wis.
Smith, C. J., General Electric Co., Cincinnati, Ohio
Sperry, E. A., Jr., (Member), Sperry Gyroscope Co., Brooklyn, N. Y.
Storms, H. J., Western Union Telegraph Co., Spokane, Wash.
Stratford-Handcock, A. G., Plastow Electric, New Westminster, B. C., Can.
Thomas, C. A., Fairbanks Morse & Co., Indianapolis, Ind.
Thoren, A. W., Westinghouse Elec. & Mfg. Co., New York, N. Y.
Whiteley, H. O., Western Electric Co., Chicago, Ill.
Wiley, W. S., Cia. Cubana de Electricidad, Havana, Cuba
Wilhelm, G. R., Chespeaker & Potomac Telephone Co., Washington, D. C.
Wilson, R. C., The Philip Carey Mfg. Co., Cincinnati, Ohio
Wolfe, R. L., Robbins & Myers, Inc., Springfield, Ohio
Total 27.

Foreign

Abigail, E. W., Shanghai Municipal Council, Shanghai, China
Banaji, P. K., (Fellow), Municipal Council, Tanjore, India
Eckmann, H. H., Chile Telephone Co., Santiago, Chile, So. America
James, J. C., P. O. Box 11, Wanganui, N. Z.
Kripalani, M. T., G. I. P. Railway, Matunga, Bombay, India
Renaud, C., Ateliers de Constructions Electriques de Charleroi, Charleroi, Belgium
Total 6.

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A. I. E. E. COMMITTEES AND REPRESENTATIVES

The list of committees and representatives is omitted from this issue, as new appointments are being made for the administrative year beginning August 1; and these will be listed in the September issue.

LIST OF SECTIONS

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Atlanta
Baltimore
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Boston
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Nebraska
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Philadelphia
Pittsburgh
Pittsfield
Portland, Ore.
Providence
Rochester
St. Louis
San Francisco
Saskatchewan
Schenectady
Seattle
Sharon
Southern Virginia
Spokane
Springfield, Mass.
Syracuse
Toledo
Toronto
Urbana
Utah
Vancouver
Washington
Worcester
Total 56.

LIST OF BRANCHES

Akron, Municipal University of, Akron, Ohio
Alabama Polytechnic Institute, Auburn, Ala.
Alabama, University of University, Ala.
Arizona, University of, Tucson, Ariz.
Arkansas, University of, Fayetteville. Ark.
Armour Institute of Technology, 3300 So. Federal St., Chicago. Ill.
Brooklyn Polytechnic Institute, 99 Livingston St., Brooklyn, N. Y.
Bucknell University, Lewisburg, Pa.
California Institute of Technology, Pasadena. Calif.
California, University of, Berkeley, Calif.
Carnegie Institute of Technology, Pittsburgh. Pa.
Case School of Applied Science, Cleveland, Ohio.
Catholic University of America, Washington, D. C.
Cincinnati, University of, Cincinnati, Ohio.
Clarkson College of Technology, Potsdam, N. Y.
Clemson Agricultural College, Clemson College, S. C.
Colorado State Agricultural College, Fort Collins, Colo.
Colorado, University of, Boulder, Colo.
Cooper Union, New York, N. Y.
Cornell University, Ithaca, N. Y.
Denver, University of, Denver, Colo.
Detroit, University of, Detroit, Mich.
Drexel Institute, Philadelphia, Pa.
Duke University, Durham, N. C.
Florida, University of, Gainesville, Fla.
Georgia School of Technology, Atlanta, Ga.
Idaho, University of, Moscow Idaho.
Iowa State College, Ames, Iowa.
Iowa, State University of, Iowa City, Iowa.
Kansas State College, Manhattan, Kansas.
Kansas, University of, Lawrence, Kans.
Kentucky, University of, Lexington, Ky.
Lafayette College, Easton, Pa.
Lehigh University. Bethlehem, Pa.
Lewis Institute, Chicago, Ill.
Louisiana State University Baton Rouge, La
Louisville, University of, Louisville, Ky.
Maine, University of, Orono, Maine.
Marquette University, 1200 Sycamore St., Milwaukee, Wis.
Massachusetts Institute of Technology, Cambridge, Mass.
Michigan State College, East Lansing, Mich.
Michigan, University of, Ann Arbor, Mich.
Milwaukee, School of Engineering of, 163 East Wells St., Milwaukee, Wis.
Minnesota, University of, Minneapolis, Minn.
Mississippi Agricultural & Mechanical College, A. & M. College, Miss.
Missouri School of Mines & Minetallurgy, Rolla, Mo.
Missouri, University of, Columbia, Mo.
Montana State College, Bozeman, Mont.
Nebraska, University of, Lincoln, Neb.
Nevada, University of, Reno, Nevada.
Newark College of Engineering, 367 High St., Newark, New Jersey.
New Hampshire, University of, Durham, N. H.
New York, College of the City of, 139th St., & Convent Ave., New York, N. Y.
New York University, University Heights, New York, N. Y.
North Carolina State College, Raleigh, N. C.
North Carolina, University of, Chapel Hill, N. C.
North Dakota Agricultural College, State College Station, Fargo, N. D.
North Dakota, University of, University Station, Grand Forks, N. D.
Northeastern University, 316 Huntington Ave., Boston 17, Mass.
Notre Dame, University of, Notre Dame, Ind.
Ohio Northern University, Ada, Ohio.
Ohio State University, Columbus, O.
Ohio University, Athens, O.
Oklahoma A. & M. College, Stillwater, Okla.
Oklahoma, University of, Norman, Okla.
Oregon State College, Corvallis. Ore.
Pennsylvania State College, State College, Pa.
Pennsylvania, University of, Philadelphia, Pa.
Pittsburgh, University of, Pittsburgh, Pa.
Princeton University, Princeton, N. J.
Purdue University, Lafayette, Indiana.
Rensselaer Polytechnic Institute, Troy, N. Y.
Rhode Island State College, Kingston, R. I.
Rose Polytechnic Institute, Terre Haute, Ind.
Rutgers University, New Brunswick, N. J.
Santa Clara, University of, Santa Clara, Calif.
South Carolina, University of, Columbia, S. C.
South Dakota State School of Mines, Rapid City, S. D.
South Dakota, University of, Vermillion, S. D.
Southern California, University of, Los Angeles, Calif.
Stanford University, Stanford University, Calif.
Stevens Institute of Technology, Hoboken, N. J.
Swarthmore College, Swarthmore, Pa.
Syracuse University, Syracuse, N. Y.
Tennessee, University of, Knoxville, Tenn.
Texas, A. & M. College of, College Station, Texas.
Texas, University of, Austin, Texas.
Utah, University of, Salt Lake City, Utah.
Vermont, University of, Burlington, Vt.
Virginia Military Institute, Lexington, Va.
Virginia Polytechnic Institute, Blacksburg, Va.
Virginia, University of, University, Va.
Washington, State College of, Pullman, Wash.
Washington University, St. Louis, Mo.
Washington, University of, Seattle, Wash.
Washington and Lee University, Lexington, Va.
West Virginia University, Morgantown, W. Va.
Wisconsin, University of, Madison, Wis
Worcester Polytechnic Institute, Worcester, Mass.
Wyoming, University of, Laramie, Wyoming.
Yale University, New Haven, Conn.
Total 101

AFFILIATED STUDENT SOCIETY

Brown Engineering Society, Brown University, Providence, R. I.

Note: Names of new officers will be printed in the September issue of the JOURNAL. Names of officers serving to July 31 may be found in the July JOURNAL.

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(August 1929) Number	Author	Title
☐ **29-67**	T. E. Shea and C. E. Lane	Telephone Transmission Networks
☐ **29-82**	B. L. Robertson and I. A. Terry	Analytical Determination of Magnetic Fields
☐ **29-87**	J. B. Cox	The Electrification of the Mexican Railway
☐ **29-91**	A. H. Kehoe	Part II "Symposium Synchronized at Load"
☐ **29-92**	H. R. Searing and G. R. Milne	Part III "Symposium Synchronized at Load"
☐ **29-103**	E. T. Norris	Safe Loading of Oil-Immersed Transformers

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NEW CATALOGUES AND OTHER PUBLICATIONS

Mailed to interested readers by issuing companies

Voltage Regulators.—Bulletin GEA-709A, 34 pp. Describes G-E automatic generator voltage-regulators. General Electric Company, Schenectady, N. Y.

Disconnecting Switches.—Bulletin 27, 2 pp. Describes Pacific Electric, type BB-1 stick-operated disconnecting switches for voltages up to 73 kv. Pacific Electric Manufacturing Corp., 5815 Third St., San Francisco, Cal.

Atlantic City Convention Hall.—Bulletin 1850, 12 pp. Describes the electrification of the new Atlantic City Convention Hall. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

Hydraulic Turbines.—Bulletin 1644, 76 pp. Describes Allis-Chalmers large hydraulic turbines and auxiliaries for low, medium and high heads. Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

Moisture Meter.—Bulletin 978, 4 pp. Describes the new Tag-Heppenstall moisture meter, a portable device for indicating the moisture content of lumber. C. J. Tagliabue Manufacturing Co., 18 Thirty-Third St., Brooklyn, N. Y.

Substations.—Bulletin 26, 8 pp. Describes Pacific Electric standard, complete substations for high voltage power transmission systems, available for quick delivery. Pacific Electric Manufacturing Corp., 5815 Third St., San Francisco, Cal.

Circuit Breakers.—Bulletin GEA-720A, 16 pp. Describes G-E high-speed circuit breakers, built in standard designs ranging from 600 to 3000 volts and in current capacities from 625 to 4000 amperes. General Electric Company, Schenectady, N. Y.

Connectors.—Bulletin 38-CC, 8 pp. Describes Sumpter compression type connectors for wire connections. No bolts are used with these connectors. Delta-Star Electric Co., 2400 Block, Fulton Street, Chicago.

Armorclad Switchgear.—Bulletin 1145, 28 pp. Describes Allis-Chalmers, Reyrolle armorclad, oil circuit-breaker equipment for power stations, substations and general industrial purposes. Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

Air-Break Switch Controls.—Bulletin 24, 8 pp. Describes Pacific Electric motor controls for the operation of group controlled air-break switches up to and including 73 kv. rating. Pacific Electric Manufacturing Corp., 5815 Third St., San Francisco, Cal.

Outdoor Switching Equipment.—Bulletin GEA-1123, 12 pp. Describes G-E fusible cutouts and current-limiting resistors. Bulletin GEA-1113, 20 pp. Describes connectors and fittings for outdoor switching equipment. General Electric Company, Schenectady, N. Y.

Amperehour Meters.—Bulletin 78, 16 pp. Describes Sangamo type "N" amperehour meters. These instruments are extensively used in storage battery installations to indicate the state of charge of the battery and to terminate the charge automatically when the battery is full. Sangamo Electric Company, Springfield, Ill.

NOTES OF THE INDUSTRY

Increased Orders for General Electric Company.—According to an announcement by President Gerard Swope, orders received by the General Electric Company for the three months ending June 30, amounted to $119,351,248 compared with $90,431,957 for the corresponding quarter for 1928, an increase of 32 per cent. For the six months ending June 30, orders received amounted to $220,716,456, compared with $170,357,797 for the first six months of last year, an increase of 30 per cent.

Larg Westinghouse Orders.—The Westinghouse Electric & Manufacturing Company has received an order from the Youngstown Sheet & Tube Company for apparatus amonting to more than one-half million dollars. This equipment covers the motors and control for use in driving a 10" and 14"-18" merchant mill to be installed in the Indiana Harbor Works of the company. Another contract, recently received from the West Leechburg Steel Company, covers the complete electric drive for a new 12" hot strip mill, to replace an old Belgian type mill.

Record Transformer by Ferranti, Ltd.—It is reported that Ferranti, Ltd., are constructing at their plant in Hollinwood, England, the largest three-phase transformer yet built. The specifications call for 132,000-volt capacity and 80,000 kw. rating. According to the announcement, the largest transformer of this type in use today has a rating of 75,000 kv-a., and this was also built by Ferranti, Ltd. The machine now under construction is the fourth of a series to be built by Ferranti, Ltd. for the British National Electricity Scheme.

Buildings by the Austin Company for the Electrical Industry.—The Pacific States Electric Co., Pacific Coast sales organization of the General Electric Co., will establish a fully-equipped sales office and warehouse in a new $125,000 reinforced concrete structure at Seattle. The warehouse is being built by the Austin Company of Cleveland, industrial architects and builders, and calls for completion in 100 working days. The Lincoln Electric Company, Cleveland, has also awarded a contract to the Austin Company for the design and construction of an all-welded warehouse for steel storage, to cost $65,000, at the Lincoln plant in Cleveland, and scheduled for completion early in September.

The Bull Dog Electric Products Company, Detroit, Michigan, has announced the following policy in relation to the manufacture of their products:

"Effective at once, we as leading manufacturers of products for electrical distribution and control shall discontinue advertising, offering for sale and manufacturing all live-face electric products not recognized and approved by the safety recommendations and rules as published by the Department of Commerce, U. S. Bureau of Standards, in accordance with the procedure of the American Engineering Standards Committee. In line with this policy, we will no longer manufacture the following: (1) Live face or open type lighting panelboards. (2) Lighting panelboards having main fuses (not switched) or fusible only subfeeds on the panels. (3) Feeder or distributing panelboards having fuses only in the branches (not switched). As heretofore, we shall continue to devote our entire energies and resources to the increased use of electricity through promotion of safety electrical products for the protection of life and property."

Enduring Insulation on Old Wire.—Insulation that has stood the test of time for thirty-six years, and that, today, possesses far greater insulating value than new code wire was brought to light recently, when the Holy Name Roman Catholic Cathedral in Chicago underwent alterations. This wire, which was installed by the Okonite Company of Passaic, New Jersey, in 1893, was given the most strenuous of physical and dielectric tests and was found to have the same breakdown qualities as new wire. The tinning on the copper conductor is bright in appearance and entirely free from corrosion. Specimens of the wire, which have no braids or other covering over the rubber insulation, were subject to a severe bending test and the insulation withstood this without cracking or checking. Dielectric strength was determined on three foot samples in water. The results obtained were equal to breakdown qualities shown by new wire of this size and wall thickness of insulation. Physical tests were made on specimens of the insulation removed from the conductor. The insulation adhered so firmly to the conductor that it was found necessary to use mercury to aid in obtaining undamaged test specimens. When it is considered that the insulation has been exposed to light and air for more than a third of a century without any protective covering, the outcome of these tests is made doubly remarkable.

JOURNAL OF THE A. I. E. E

DEVOTED TO THE ADVANCEMENT OF THE THEORY AND PRACTISE OF ELECTRICAL ENGINEERING AND THE ALLIED ARTS AND SCIENCES

The Institute is not responsible for the statements and opinions given in the papers and discussions published herein. These are the views of individuals to whom they are credited and are not binding on the membership as a whole.

Vol. XLVIII SEPTEMBER, 1929 Number 9

A Message From the President.

The Interrelationship of the Section and the Section Member.

THE message appearing on this page of the August Journal may have some of its applications emphasized. The Section is that integral part of the American Institute of Electrical Engineers designed to carry the spirit and stimulus of the whole body to the individual member. These centers of Institute life are being so effectively distributed throughout the country that we may expect to see such a focus accessible to almost every member of the Institute.

What are the interrelated responsibilities and advantages of the Section and its members?

The electrical engineer, whether a member of the Institute or not, is frequently isolated to a degree depending upon personal characteristics, environment, location, etc. Except in rare cases, inaccessibility of a Section is no longer a reason for lack of association. In some cases, more of isolation and less of inspiration may be found in our larger cities than obtains upon the prairies or in the mountains. A function of the Section is to reduce that isolation in so far as the Section member will permit. The individual cannot fully develop himself without that contact and stimulus to thought and endeavor which Section life should, and does, afford. Each person has his own reservoir of vital, useful thought and inspiration which, for lack of flow, may stagnate or evaporate, and which, allowed copiously to overflow, requires refreshment and replenishment. Is it not the responsibility of the member to allow himself to be drawn upon by the Section, and likewise, is it not the responsibility of the Section to act as source to the member? Herein lies that interrelated advantage to both which, through adherence and application of Institute ideals,* evolves the valuable and effective engineer and citizen.

Recognizing that each Section must work out the detail of its own activities in accordance with its own needs and the wishes of its members, there are at least four elements requisite for the life and usefulness of any Section, and to be applied in proportion to its particular requirements. Frequent, ordinarily monthly, meetings may involve yearly:

a. Five to ten meetings of a professional character for member contact, experience, stimulation, information and development through interchange of thought and experience. This opportunity the Section usually supplies. It depends upon the member to make the most of this for personal development.

b. Occasional meetings, possibly annual, of a distinctly social or "entertainment" character for contact and good fellowship.

c. The Section, through its district organization, should, at least once a year, bring to itself the best of its district membership, its Vice-President or other able engineer.

d. The Section, through cooperation of the district and national organizations, should bring, at least once a year, and usually from outside of the district, the best that the national membership has to offer of stimulation, leadership, or professional ability.

Where there is a *will* on the part of the Section to secure such result, the means to accomplish it are at hand and no electrical engineer could then afford to refrain from active Section membership in the American Institute of Electrical Engineers.

Harold B. Smith

President

*See Code of Principles of Professional Conduct, Sections 16 and 20.

Some Leaders of the A. I. E. E.

Norman Willson Storer, Manager of the Institute 1911-1914, one of its Vice-Presidents for 1914-1916 and 1921-1923, and now Consulting Railway Engineer for the Westinghouse Electric & Manufacturing Company, East Pittsburgh, is a native of Orangeville, Trumbull County, Ohio. After completing work in the public schools and a preparatory course, he took a course at Ohio State University, from which he was graduated in 1891 with the degree of M. E. in E. E. He immediately joined the Westinghouse company, spending the first four months in the winding room, with work on transformer coils and field and armature coils for No. 3 single-reduction railway and special ring type d-c. generator armatures. Another four months was spent making a complete set of tests on the No. 3 railway motor and developing curves. The next three months were occupied in the drawing-room, followed by eight months in charge of new lines of a-c. generators, and synchronous and induction motors, including those exhibited at the World's Fair. In May 1893 he started in design work as first assistant to Benjamin G. Lamme, developing a line of small d-c. multipolar generators and motors,—the standard of the company for 10 years or more. He was in general charge until 1904. During this time, several complete lines of engine type generators as well as belted generators were developed and built for all classes of service. The ventilated armature windings and core were developed and applied to all machines. In 1895 laminated poles were introduced in the railway motor.

In the early days, the rating and application of street railway motors was largely a matter of guess work, there being no adequate method for connecting up the capacity of the motor with the service requirements. The only rating was the so-called nominal or one-hour rating, which served only as a rough means of comparison of two motors but did not give sufficient data for applying motors successfully. The need for a different method of rating was apparent and a number was proposed, all of which were either incorrect in principle or too complicated in application to be acceptable. Mr. Storer who, had given the subject much thought, outlined a method of rating or defining motor capacity, enabling the engineer to predict service capacity and apply a motor very accurately. The method consisted of finding the root-mean-square current required by the motor in a given service, which could be taken from test or typical speed-time curves, making a continuous test of the motor in the shop at that current and the voltage which would give the average core loss in service. This resolved itself into giving a motor both a one-hour rating and continuous rating, the latter being in terms of amperes at 300 and 400 volts (for 600-volt motors). The method, at once so simple, accurate and easy to apply, met with immediate success, and was later adopted by the Institute and also by the International Electrotechnical Commission as standard.

Mr. Storer presented a brief paper before the Institute, calling attention to the importance of inertia of the rotating parts of a car in calculating rates and power requirements for acceleration. He proposed a simple approximation which has since been generally used. The inertia of the armatures, wheels, etc., *had never before* been considered in electric railway practise. In 1904 he was appointed Engineer of the Railway Division of the Engineering Department, of his company in charge of all railway development work, including railway motors, multiple unit control and electric locomotives. In those 8 years, the a-c. d-c. passenger locomotives both gearless and geared, and the freight switcher locomotives for the New York, New Haven & Hartford Ry. were developed; also several experimental locomotives including that adopted for the Pennsylvania terminal at New York, the a-c. locomotives for St. Clair Tunnel, Hoosac Tunnel, and the first 1500-volt d-c. locomotives ever built, which were applied on the Piedmont & Northern Railway. With the advent of the commutating poles for railway motors, the use of field control for efficient operation, and speed control, which had been abandoned years before on account of commutator troubles, was again brought into general use. It was used on the New Haven locomotives in the d-c. zone, the Pennsylvania locomotives, subway, street car, and interurban railways. Since 1912, Mr. Storer's work has been along general lines. He was responsible for the use of six motors giving ⅓, ⅔, and full speed, as well as the scheme of regenerative braking and other features on the 3000-volt d-c. Milwaukee locomotive; he designed the motors and control used on the 5000-volt experimental car which was run on the Grass Lake Line of the Michigan Railways in 1915-1917. This was the highest d-c. voltage ever used in commercial railway service and was a complete success.

He designed the flash suppressor for the 3000-volt generators used on the Chicago, Milwaukee & St. Paul Railway, making it possible to short-circuit the generators without causing a flashover or serious sparking. He was largely responsible for the development of the single-phase motor-generator type locomotives used on the Detroit & Ironton Railway of the Ford Motor Company, and the Cascade Tunnel Division of the Great Northern Railway. He has also taken an active part in the development of oil electric cars and locomotives.

Beside his work as Chairman of Institute Subcommittee on Standards for several years, and his contributions of many papers along the lines of railway electrification, he has been Chairman of Advisors on Traction Motors for the U. S. National Committee of the I. E. C.

He joined the Institute in 1895 and became a Fellow in 1913. Beside other technical societies, he is a member of American Society of Mechanical Engineers, the Engineers Society of Western Pennsylvania, Pittsburgh Railway Club, and of the Engineers Club of New York, and of the University Club in Pittsburgh.

Flames from Electric Arcs

BY J. SLEPIAN[1]
Fellow, A. I. E. E.

Synopsis.—The origin of flames from arcs is considered. Their low dielectric strength is attributed to ionization, and their rate of recovery of normal dielectric strength is computed. The large influence of temperature is brought out. Computations are given and experiments described which show how flames can be reduced by passing the arc gases through narrow channels.

FLAMES FROM ELECTRIC ARCS

IT is well known that heavy current arcs in air such as occur in switches of usual construction give off large volumes of luminous gases or flames. These flames have a large volume in comparison to the arc itself which forms a core of comparatively small section, and it is quite certain that they have a much lower temperature and much lower electrical conductivity than the arc core itself.[2] Nevertheless these flames constitute one of the most troublesome features of switching in air in circuits of more than a few hundred volts, because they have a very small dielectric strength and will cause breakdown if they bridge live parts. This low dielectric strength persists for a relatively long time, and because of their large volume, considerable clear space must be provided in which these flames may dissipate themselves.

I. ORIGIN OF FLAMES

In general, these flames consist of gases which have passed through the arc core itself. The temperature of the arc core is more than 2500 deg. cent.[3] and hence the density of the air or gas there is one-ninth or less of the density of the air originally occupying the arc core space. The air displaced by the formation of the arc core will thus make up some of the flame, and if the flame temperature is more than 1000 deg. cent., will occupy a volume more than four times the volume of the arc core. This, however, will account for only a small portion of the arc flame.

The motion of the air in the neighborhood of the arc while it is playing, probably accounts for a great deal more of the flame. When the motion of the air is regular, (stream line motion) and such as does not tend to change the cross-sectional area of the core, the arc will merely move with the air, and little air will pass through the arc core itself. When, however, the motion of the air is such as to tend to increase the cross-sectional area of the core, and particularly when the air motion is turbulent, then a considerable volume of air will pass through the arc core. Such turbulent motion is to be expected from the magnetic reactions in a heavy current arc and when an arc is moved laterally very rapidly as in a magnetic blowout switch.

The gases and vapors given off by the electrodes will also contribute very largely to the flame. When the end products of the combustion of the electrode materials are gases, as in the case of carbon for example, the contribution of large volumes to the flame will be apparent; but also when the electrode vapors may be expected to condense to finely divided solids or liquids in the relatively cool flame, as in the case of copper and other metals, the projection of large volumes of vapor from the electrodes longitudinally into the arc will cause a turbulent motion which will bring large volumes of air through the arc core.

Flames will also result from gases which do not pass through the arc core, if the arc passes near a material which is decomposed by heat into an easily combustible gas. Thus if the inner faces of the arc chute of a switch are lined with fiber, paper, or similar material, a great increase in the volume of flame will result. In fuses of the expulsion type where the arc plays in a fiber tube, a large part of the flame is probably due to burning decomposition products of the fiber.

II. LOW DIELECTRIC STRENGTH OF FLAMES DUE TO IONIZATION

The dielectric strength of the flames from arcs is astonishingly low. Many instances are known where the flames from arcs caused breakdown between parts having potential differences of less than one thousand volts, and separated by inches through the air. The normal breakdown between such electrodes would be 50,000 volts or more.

This very low dielectric strength indicates that the flames are in a state of considerable ionization, a conclusion which would be reached from their luminosity also. If the flames were only very slightly ionized, like ordinary air, we should expect a dielectric strength approximately proportional to their density, that is reduced from normal only three or four fold. The presence of ions in large numbers causes the field produced by an applied potential to be considerably distorted, so that the breakdown voltage is lowered very considerably, and made approximately independent of electrode separation. This is explained in the author's paper, *Extinction of an A-C. Arc,* (A. I. E. E. Quarterly TRANS., Vol. 47, October 1928, p. 1398).

The flame gases which have passed through the arc

1. Consulting Research Engineer, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

2. Hagenbach, "Der Elektrische Lichtbogen," *Leipzig,* 1924, p. 257.

3. *Ibid.,* p. 216.

Presented at the Pacific Coast Convention of the A. I. E. E., Santa Monica, Calif., Sept. 3-6, 1929. Printed complete herein.

29-130

core are of course intensely ionized at the moment they leave the core. Recombination reduces the density of ionization very rapidly at first, but later the rate of recombination becomes much smaller so that ionization may persist for some little time.

The temperature of the flame gases very shortly after they leave the core is far too low to account for any ionization on a purely thermal basis, as may be seen by calculating from Saha's equation.[4] The only other obvious source of ionization is chemical effects such as arise in combustion flames.[5] Where there are combustible materials in the flame this ionization may persist for a long time, since the rate of combustion is limited by the rate of diffusion of oxygen into the flame which is a relatively slow process.

III. Dielectric Strength of an Ionized Gas

In the paper, *Extinction of an A-C. Arc,* referred to above, the following formula is derived for the breakdown voltage of ionized air.

$$V = 2.42 \times 10^{13} \times \left(\frac{273}{T + 273}\right)^2 \times \frac{1}{n} \qquad (1)$$

Here V is the breakdown voltage, T is the absolute temperature, and n is the number of ion pairs per cm.[3] of the gas. It will be noticed that the distance between the electrodes does not appear in the equation.

This equation, which must be regarded as only very approximate, was derived by considering conditions in the layer of air immediately adjacent to the cathode. On the application of voltage, this layer becomes at once denuded of electrons, and until breakdown occurs, bears practically the whole impressed voltage.[6] The thickness of this layer for a given impressed voltage was calculated on the hypothesis that the positive ions were relatively immovable in space, and breakdown was assumed to occur when the maximum gradient in this layer reached $30{,}000 \times \dfrac{273}{273 + T}$ volts per cm.

Actually, the positive ions do move, and their motion will cause the gradient in the cathode gas layer to be considerably less than calculated. Also the gradient for breakdown at lower voltages is much greater than $30{,}000 \times \dfrac{273}{273 + T}$ volts per cm. Equation (1) then can only be used to give very rough orders of magnitude. It can be very useful, however, in bringing out the strong influence of the temperature of the gas, and the value of any means for reducing the density of ionization of the gas.

4. *Phil. Mag.*, 40, 1920, p. 972.
5. *Handb. d. Physik*, Geiger & Scheel, Berlin, 1927, Vol. XIV, p. 190.
6. For detailed quantitative treatment of the physics of these deionized sheaths around electrodes in ionized gases see Langmuir & Mott Smith, *General Elec. Rev.*, Vol. XXVII, 1924, pp. 449, 538, 616, 762, 810.

IV. The Decay of Ionization in a Gas

Immediately after leaving the arc core, if the gases are not exposed to deionizing surfaces of solids, the density of ionization is practically entirely determined by the rate of recombination of the ions. This rate of recombination is proportional to the density of positive ions and also to the density of negative ions, so that we have[7]

$$-\frac{dn}{dt} = \alpha\, n^2 \qquad (2)$$

If α, the recombination constant, was really constant in time Equation (2) could be readily integrated giving

$$\frac{1}{n} - \frac{1}{n_0} = \alpha\, t \qquad (3)$$

n_0 being the initial density of ionization, and if n_0 is very large, as it is in the arc core itself, $\dfrac{1}{n_0}$ is negligible and Equation (3) becomes

$$n = \frac{1}{\alpha\, t} \qquad (4)$$

Plimpton[8] has found that α for ions generated by X-rays shows an aging effect, being considerably smaller for older ions than for newly formed ones. This result may, however, be due to the non-uniform distribution of ions formed by X-rays. For air at normal pressure and temperature several investigators have found $\alpha = 1.6 \times 10^{-6}$ for "aged" ions. α is found to be greatly affected by the temperature, increasing very rapidly as the flame cools. Meager experimental data show that α varies inversely as the cube of the temperature. Equation (2) might then be better written

$$-\frac{dn}{dt} = \alpha\,(t, T)\, n^2 \qquad (5)$$

showing explicitly the dependence of α upon the time t, and absolute temperature T.

However, since it is not the purpose of this paper to determine actual numerical values of the dielectric strength of arc flames, but merely to get orders of magnitude and to show the great influence of temperature, we shall work with the following assumptions:

1. We shall take the value of α for air at normal pressure and temperature to be 7.6×10^{-6}.
2. We shall assume that the flame gases, immediately upon leaving the arc core, take on the absolute temperature T, and keep that value of temperature thereafter. We shall assume that α varies inversely as the cube of the absolute temperature. Thus

$$\alpha = 7.6 \times 10^{-6} \times \left(\frac{273}{T + 273}\right)^3 \qquad (6)$$

7. Townsend, "Electricity in Gases," *Oxford*, 1913, Chap. VI.
8. *Phil. Mag.*, (6), 25, 1913, p. 63.

V. The Dielectric Strength of Flames from Arcs

From the standpoint of the designer of switches, it is the dielectric strength of flames from arcs which is important, rather than their luminosity, temperature, or other properties. Where the ionization of the flames is almost entirely residual, or that is, where there is little combustible material in the flames, Equations (1), (4), and (6) above serve to determine the dielectric strength of the arc flame as a function of the flame temperature T and the time t, in the resultant equation

$$V = 1.84 \times 10^9 \left(\frac{273}{T + 273} \right)^5 t \qquad (7)$$

A few numerical values will best bring out the significance of Equation (7) and particularly the great influence of the temperature. Consider the dielectric strength of the flame 0.01 sec. after it has left the core of the arc, during which time it may have traveled several feet.

DIELECTRIC STRENGTH OF FLAME
0.01 Seconds after leaving arc

Temperature of gas	Density of ionization ion pairs/cm.[2]	Dielectric strength volts
2000°C	7.6×10^9	450
1500°C	3.6×10^9	1,610
1000°C	1.3×10^9	8,300
500°C	3.0×10^8	98,500
0°C	1.3×10^7	1,840,000

The advantage gained by cooling the flame gases, which is considered desirable instinctively by switch designers, is forcibly brought out in the table. However, the direct instantaneous effect of lowering the flame temperature is only slight. The great increase in dielectric strength follows the lowered temperature shortly in time as a result of the large increase in the recombination rate of the ions in the cooler gas.

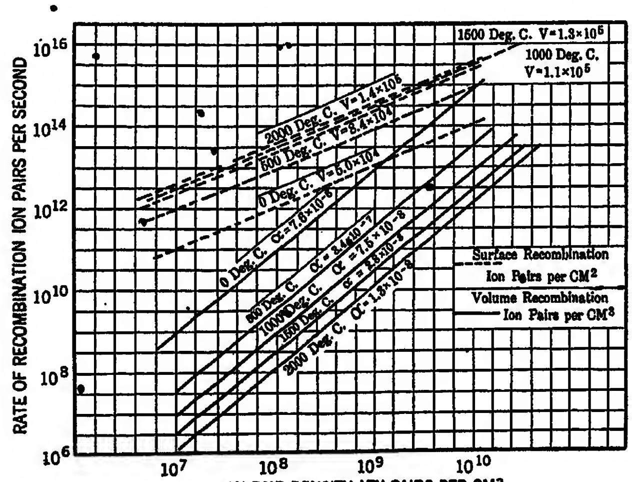

Fig. 1

VI. Recombination of Ions at Surfaces of Solids

When an ionized gas is exposed to the surface of a solid, ions are lost by diffusing to the surface and being caught and recombining there. Under proper circumstances this loss of ions to surfaces of solids may far exceed the loss by recombination in the volume of the gas.

The rate of loss of ions to a surface will be given by

$$N = \frac{1}{4} n \nu \qquad (8$$

where n is the density of ions in the gas adjacent to the surface, ν is the mean velocity of agitation of the ions, and N is the number of ions reaching the surface per

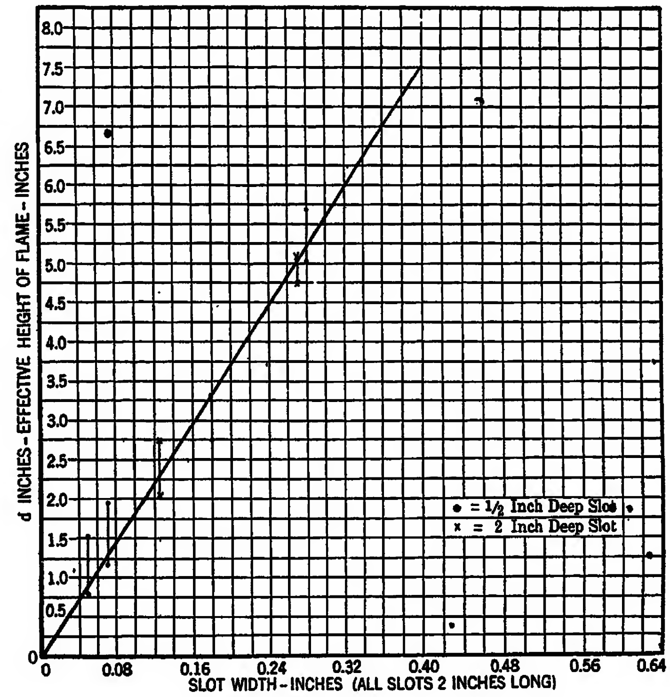

Fig. 2

cm.[2] per sec.[9] When the velocity of agitation of the ions of one sign exceeds that of the ions of the other sign, an electric field sets itself up at the surface which retards the faster ion, so it is the velocity of the slower ion which must be used in Equation (8).

The curves of Fig. 1 give a comparison of the recombination rates of ions at a surface with the recombination rates of ions in the volume of the gas for conditions which are of practical importance in the flames from switch arcs. We see that the recombination rate per cm.[2] of surface is 100 to 1,000,000 times as great as the recombination rate per cm.[3] of the gas immediately adjoining.

If the gas is at rest relative to the surface, the layer of gas immediately adjacent to the surface becomes very quickly denuded of ions, and then ions which further reach the surface must diffuse through this layer of deionized gas. The surface then loses most of its deionizing efficacy. If, however, the gas is in rapid turbulent motion past the surface, fresh portions of the

9. Langmuir & Mott-Smith, *General Elec. Rev.*, XXVII, 1924, p. 450.

ionized gas are constantly exposed to the surface, and its deionizing activity is maintained.

VII. Experiments of C. L. Denault on Reduction of Flames from Arcs

The considerations given above of the influence of temperature and the deionizing effect of surfaces would lead one to expect that the flames from arcs would be greatly reduced in volume if the gases from the arcs were compelled to pass through narrow channels between solid walls. This is beautifully confirmed by experiments of C. L. Denault (which have not yet been published).

In these experiments an arc was formed by blowing a fuse in a soapstone chamber with an open top, 9/16 in. by 2-1/8 in. and 1-9/32 in. high. Covers were then placed over the chamber which compelled the escaping flame to pass through slots of various widths. A spark gap consisting of ½-in. diameter brass roads with rounded ends, separated 0.9 in., and with 2200 volts 60 cycles impressed upon it, was used to determine the effective height of the flame, by determining what was the shortest distance above the vent at which the spark gap could be placed without breaking down. The breakdown voltage of the spark gap in normal air was 30,000 volts.

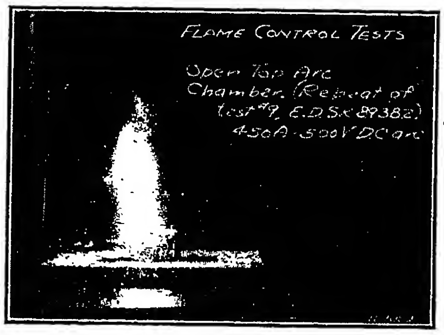

Fig. 3

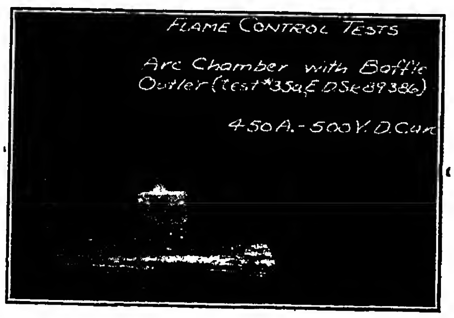

Fig. 4

The curve of Fig. 2 and the photographs in Figs. 3 and 4, show the remarkable reduction in flame obtained by exposing the arc gases to deionizing surfaces.

VIII. The Deion Contactor

Recently contactor switches have been developed which use a weak blowout magnetic field and which extinguish the arc by means of a column of deionizing metal plates. These switches show an enormous reduction of flame in comparison with previous types of switches.

In the Deion contactor by the use of the deionizing plates the arc length has been considerably shortened, which in itself would cause a reduction in the total volume of arc flame. The arc is in a weaker magnetic field, which reduces the amount of air carried turbulently through the arc core, and therefore also the volume of flame. Lastly, before escaping from the switch the flame gases pass through 1/16-in. channels between the deionizing plates where they are effectively cooled and deionized.

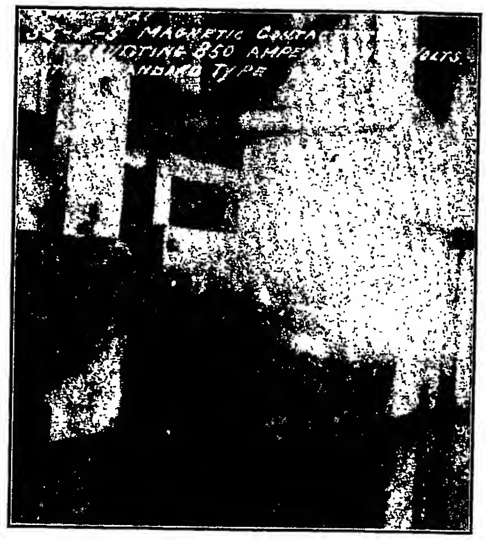

Fig. 5

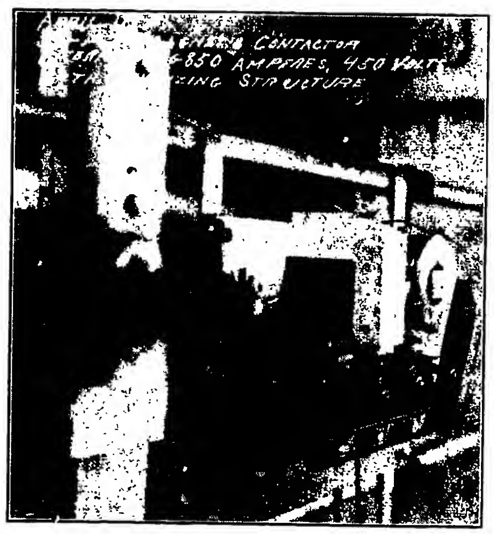

Fig. 6

Figs. 5 and 6 show a comparison of the amount of flame emitted by a magnetic blowout contactor of the usual type, and a Deion contactor. The size of arc box is the same for the two switches, and the arc current is of the same magnitude. The absence of flame from the Deion contactor is quite remarkable.

Abridgment of

Electric Heating Elements

Some Fundamentals Used in Their Design

BY EDWIN FLEISCHMANN*
Member, A. I. E. E.

Synopsis.—*The paper presents the derivation from elementary principles of equations for the design of heating elements. These are then connected with Stefan's law of radiation, and also with a much-used rating curve which has given good results. The reason for the conservatism of this latter curve is shown, and a numerical example worked out for both the theoretical and empirical curves.*

INTRODUCTORY

THE classical basis upon which the theory of electric heating design rests, need only be suggested. It is founded on several well-known electrical and thermal laws,—for example, those of Ohm, Wien and Planck, and the familiar Stefan-Boltzman equation. To be sure, certain data which are based solely upon fortuitous experiment have been useful; but the fundamental relationships must not be ignored. It is the purpose of the present paper to outline briefly some principles in the use of electricity for heat, pointing out particularly those basic ones which govern its skilful employment.

In this paper, attention is confined to metallic resistors for high-temperature work (up to 1850 deg. fahr.). It is here that the upper safe value of the operating temperature of the heating unit is approached.

MATERIAL FOR HEATING ELEMENTS

For temperatures up to 1850 deg. fahr., there is really only one material from which a practical life can be obtained. This is an alloy containing normally about 80 per cent nickel and 20 per cent chromium, with practically no iron. The susceptibility of iron to oxidation endangers the life of the metal at elevated temperatures; so that in the best metals it is carefully avoided. The alloy has the property of forming upon its surface a complicated metallic layer, of which the metallography is still not clearly understood. It is known, however, that this coating effectively prevents further oxidation of the body of the material below 2100 deg. fahr. (1150 deg. cent.). Thus, it assures the life of the element at ordinary heat-treating temperatures.

As indicated by the curves in Fig. 1, the resistivity of nickel chromium is consistent and fairly uniform.

OHM'S LAW

The familiar law of Ohm states that

$$E = I\,R \tag{1}$$

where I = the current in amperes,
E = the impressed voltage, and
R = the resistance in ohms.

The power in watts is the product of E and I, or

$$E\,I = I^2\,R \tag{2}$$

A variant form of Equation (2) may be obtained by substituting for I its value E/R from (1):

$$E\,I = \frac{E^2}{R} \tag{3}$$

The general expression for resistance of a conductor at any temperature is

$$R = m\,\rho\,\frac{L}{A} \tag{4}$$

where
R is the resistance in ohms,
m is a constant for any given temperature expressing

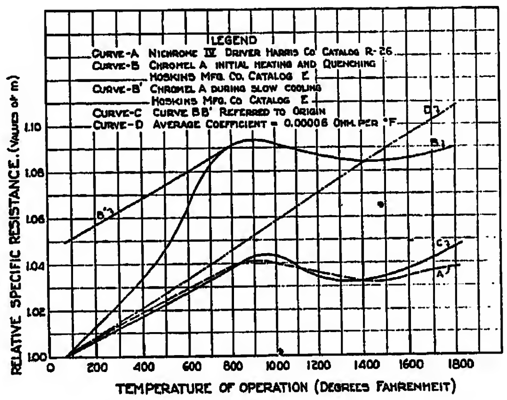

FIG. 1—RESISTANCE OF NICKEL-CHROMIUM AT ELEVATED TEMPERATURES

the ratio of the resistivity at that temperature to the resistivity at some temperature of reference. For nickel chromium, the values of m are shown in Fig. 1.

ρ is the specific resistance, or resistivity at the temperature of reference. In the case of nickel chromium, the value of ρ is 625 ohms per cir. mil-ft., or 0.00004091 ohms per in. of length per sq. in. of cross-sectional area. The latter figure will be used hereafter, because we shall define

L as the length in in., and

A as the cross-sectional area in sq. in.

If, now, this value of R be substituted in Equations (2) and (3), they become

$$E\,I = \frac{I^2\,m\,\rho\,L}{A} \tag{6}$$

*Industrial Heating Engineer, The Niagara Falls Power Co.
Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

and,
$$E\,I = \frac{E^2 A}{m\,\rho\,L} \tag{8}$$

There is no difficulty in applying the laws to other shapes. The equations already derived, (4), (6), and (8), are perfectly general. The geometrical simplicity of the rectangular and circular cross-section recommends them for this elementary discussion.

The cross-sectional areas in the two cases will be:

Round Rod	*Flat Ribbon*
$A = \frac{1}{4}\pi D^2$ (10a)	$A = a\,b$ (10b)
where D is the diameter of the rod in in.	where a is the width of the ribbon in in., and b is the thickness of the ribbon in in.
$E\,I = \frac{4\,m\,\rho\,I^2\,L}{\pi D^2}$ (11a)	$E\,I = \frac{I^2\,m\,\rho\,L}{a\,b}$ (11b)
$E\,I = \frac{\pi E^2 D^2}{4\,m\,\rho\,L}$ (13a)	$E\,I = \frac{E^2\,a\,b}{m\,\rho\,L}$ (13b)

The wattage per sq. in. can be related to the physical dimensions of the heating unit itself. If the peripheral surface of the resistor be denoted by S,

Round Rod	*Flat Ribbon*
$S = \pi\,D\,L$ (15a)	$S = 2\,(a + b)\,L$ (15b)

The wattage per sq. in. of surface will, then, be $E\,I/S$. For convenience, set

$$G = E\,I/S \tag{16}$$

Then, using this value, and, for

Round Rod	*Flat Ribbon*
dividing by (15a),	dividing by (15b),
$G = \frac{4\,I^2\,\rho\,m}{\pi^2 D^3}$ (17a)	$G = \frac{I^2\,\rho\,m}{2\,a\,b\,(a + b)}$ (17b)

And, in a similar manner,

dividing (13a) by (15a),	dividing (13b) by (15b),
$G = \frac{E^2 D}{4\,m\,\rho\,L^2}$ (19a)	$G = \frac{E^2\,a\,b}{2\,m\,\rho\,L^2 (a + b)}$ (19b)

Several simple transformations suggest themselves. One is often interested in the current density in the conductor. The density

$$Q = I/A \tag{21}$$

whence, for

Round Rod	*Flat Ribbon*
$Q = \frac{4\,I}{\pi D^2}$ (22a)	$Q = \frac{I}{a\,b}$ (22b)

and,

$I = \frac{\pi}{4}\,Q\,D^2$ (23a)	$I = Q\,a\,b$ (23b)
$G = \frac{1}{4}\,Q^2\,\rho\,D\,m$ (24a)	$G = \frac{Q^2\,m\,\rho\,a\,b}{2\,(a + b)}$ (24b)

In short the wattage per sq. in. of the surface varies with the square of the current density, for any given cross-section.

The voltage per unit length may also be of importance, in its relation to the wattage per sq. in. of surface. This appears very easily from Equation (19). Setting F equal to the voltage per in. of length, and F' equal to the voltage per ft. of length,

$$F = E/L \tag{26}$$

$$F' = \frac{12\,E}{L} \tag{27}$$

Round Rod	*Flat Ribbon*
$G = \frac{F^2 D}{4\,\rho\,m}$ (28a)	$G = \frac{F^2\,a\,b}{2\,m\,\rho\,(a + b)}$ (28b)
$G = \frac{F'^2 D}{576\,\rho\,m}$ (30a)	$G = \frac{F'^2\,a\,b}{288\,m\,\rho(a+b)}$ (30b)

Stefan-Boltzman Law

The Stefan-Boltzman equation is an hypothesis guessed at by Stefan[1] in 1879 as a result of one of Tyndall's experiments, and conclusively proved by Boltzman[2] mathematically in 1884, being substantiated by many subsequent investigations. It states that the total radiation from a body is proportional to the fourth power of its absolute temperature:

$$R = K\,T^4 \tag{32}$$

where

R is the total radiation per unit of surface in fundamental units;

T is the absolute temperature on the Kelvin scale; and

K is the constant of proportionality.

The equation is not very useful in this form, since the total radiation is scarcely ever of much import. Rather is the exchange of heat between hot and cold bodies, or between resistor and charge in the furnace chamber of interest. R may, therefore, be expressed in watts per sq. in. of radiating surface, and

$$G = K'\,e\left[\left(\frac{T_1 + 459.4}{1000}\right)^4 - \left(\frac{T_0 + 459.4}{1000}\right)^4\right] \tag{33}$$

wherein

K' is the constant of proportionality;

e is the relative emissivity of the radiating material. For black bodies, $e = 1.00$; for nickel chromium, $e = 0.9$;

1. *Sitzungsberichte der Königlichen Gessellschaft der Wissenschaften zu Wien*, Band LXXIX, p. 391, 1879.
2. *Annalen der Physik*, Band XXII, pp. 31 and 291, 1884.

T_1 is the temperature of the resistor in deg. fahr.; and
T_0 is the temperature of the furnace chamber in deg. fahr.

Frequently, however, the full effect of the radiating periphery is not obtained. Proximity of walls or charge, or adjacent strands of the element exercise a blanketing effect, which reduces the liberation of heat at any given temperature.[10] Where the efficiency of radiation is less than 100 per cent under such conditions as those described by Keene and Luke, Fig. 2 defines the limiting allowable conditions for design of nickel chromium units. It is based upon a maximum allowable element temperature of 2100 deg. fahr. To insure long life of the heaters, their rating must fall below the curve which represents the condition of size, spacing, and radiating efficiency (C) under consideration.

Combinations of the Two Laws

It is at once evident that in designing resistors, both of the laws must be heeded; and some very useful relationships can be adduced, by substituting the values of G in Equation (34). For this purpose, set $T_1 =$ 2100 deg. fahr., and write

$$G_0 = 3.169\, C \left[42.85 - \left(\frac{T_0 + 459.4}{1000} \right)^4 \right] \qquad (37)$$

in which C is the radiating efficiency already defined, as shown in Fig. 2.

Round Rod		*Flat Ribbon*	
$D = 0.7401 \sqrt[3]{\dfrac{I^2 \rho\, m}{G_0}}$	(38a)	$a\, b\, (a + b) = 0.5 \dfrac{I^2 \rho\, m}{G_0}$	(38b)
$D = \dfrac{4\, m\, \rho\, G_0\, L^2}{E^2}$	(40a)	$\dfrac{a\, b}{a + b} = \dfrac{2\, m\, \rho\, L^2\, G_0}{E^2}$	(40b)
$D = \dfrac{4\, G_0}{Q^2\, m\, \rho}$	(42a)	$\dfrac{a\, b}{a + b} = \dfrac{2\, G_0}{Q^2\, m\, \rho}$	(42b)
$D = \dfrac{4\, m\, \rho\, G_0}{F^2}$	(44a)	$\dfrac{a\, b}{a + b} = \dfrac{2\, m\, \rho\, G_0}{F^2}$	(44b)
$D = \dfrac{576\, m\, \rho\, G_0}{F'^2}$	(46a)	$\dfrac{a\, b}{a + b} = \dfrac{288\, m\, \rho\, G_0}{F'^2}$	(46b)

The values of G_0 for any temperature and radiating efficiency may be taken directly from Fig. 2.

For any value of C, these relationships provide complete design data. In the case of the round rod, they may be plotted. (Fig. 3).

10. A discussion of the relative efficiency of several arrangements of heating units may be found in *Rating of Heating Elements for Electric Furnaces*, by A. D. Keene and G. E. Luke, A. I. E. E. Transactions, Vol. XLV, 1926, p. 475

Empirical Relationships

The straight line,

$$G = \frac{2100 - T_0}{30} \qquad (53)$$

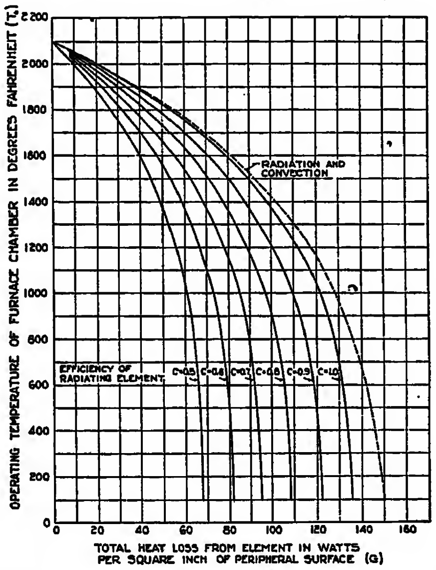

Fig. 2—Theoretical Radiation from Nickel-Chromium Resistor Operating at 2100 Deg. Fahr.

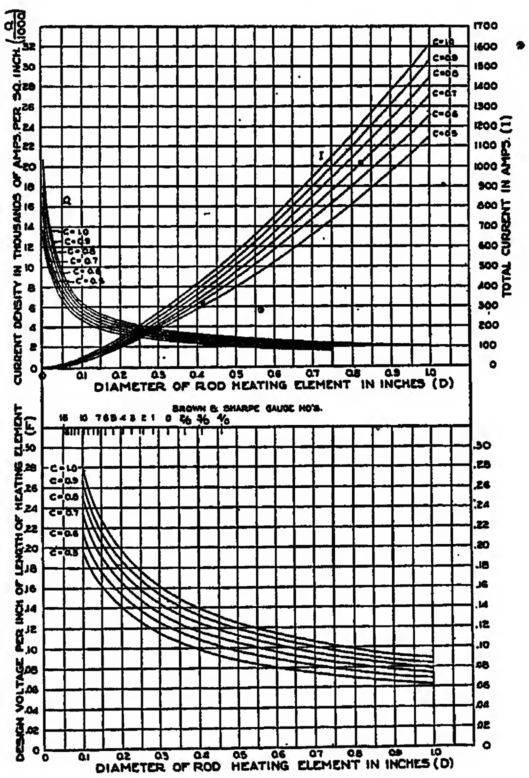

Fig. 3—Theoretical Design Curves for Nickel-Chromium Rod Heating Elements in Electric Furnaces Operating at 1850 Deg. Fahr.

is shown in Fig. 4 (Curve B), in its relation to curve A,—50 per cent radiating efficiency replotted from Fig. 2. It is evident that the line gives an extremely conserva-

tive rating, especially at moderate temperatures, even under such conditions as the double banking or close spacing of units.

Substituting for G its value

Round Rod		*Flat Ribbon*	
$T_0 = 2100 - \dfrac{120\, I^2\, \rho\, m}{\pi^2 D^3}$	(55a)	$T_0 = 2100 - \dfrac{15\, I^2\, \rho\, m}{a\, b\, (a+b)}$	(55b)
$T_0 = 2100 - 7.5\, \dfrac{E^2 D}{m\, \rho\, L^2}$	(57a)	$T_0 = 2100 - 15\, \dfrac{E^2\, a\, b}{m\, \rho\, L^2\, (a+b)}$	(57b)
$T_0 = 2100 - 7.5\, Q^2\, \rho\, D\, m$	(59a)	$T_0 = 2100 - 15\, \dfrac{Q^2\, m\, \rho\, a\, b}{(a+b)}$	(59b)
$T_0 = 2100 - 7.5\, \dfrac{F^2 D}{\rho\, m}$	(61a)	$T_0 = 2100 - 15\, \dfrac{F^2\, a\, b}{m\, \rho\, (a+b)}$	(61b)
$T_0 = 2100 - \dfrac{F'^2 D}{19.2\, \rho\, m}$	(63a)	$T_0 = 2100 - \dfrac{F'^2\, a\, b}{9.6\, m\, \rho\, (a+b)}$	(63b)

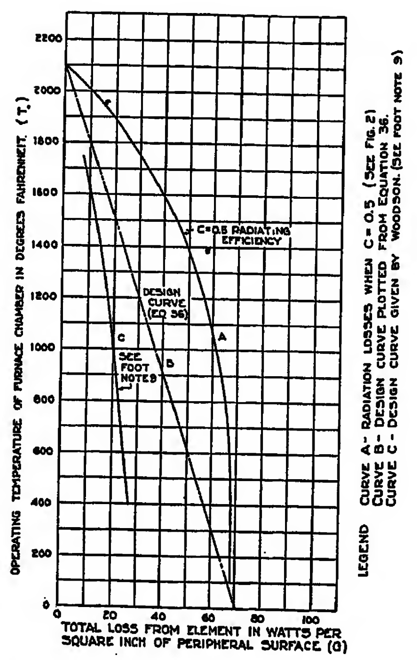

FIG. 4—COMPARISON OF THEORETICAL WITH OTHER RADIATION CURVES FOR NICKEL-CHROMIUM HEATING ELEMENT TEMPERATURE OF 2100 DEG. FAHR.

NUMERICAL EXAMPLE

For example, assume that it is desired to design the heating elements for a 20-kw. furnace, to operate on 220 volts, single-phase, with maximum operating temperature of 1850 deg. fahr. and $C = 0.5$.

The designer may choose whichever of the elements best suits the space available in the furnace and the manner of mounting. The theoretical values are as follows:

Round Rod	*Flat Ribbon*
125.6 ft. of No. 4 wire	36.86 ft. of 1-in. × 0.008-in. ribbon
	51.65 ft. of ¾-in. × 0.0159-in. ribbon
	71.77 ft. of ½-in. × 0.032-in. ribbon

Conservative practise dictates that the empirical values provide some factor of safety; and, although

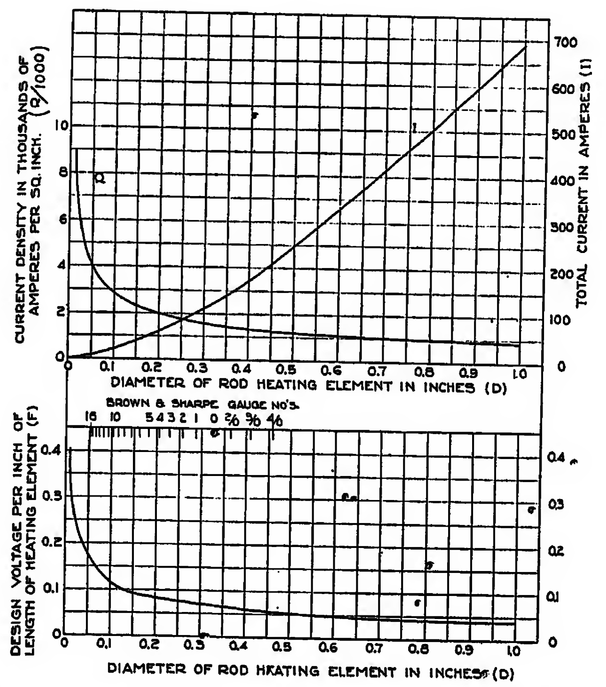

FIG. 5—DESIGN CURVES FOR NICKEL-CHROMIUM ROD HEATING ELEMENTS IN ELECTRIC FURNACES OPERATING AT 1850 DEG. FAHR. (BASED ON CURVE B, FIG. 4)

they involve the use of more metal, they mean lower ratings, decreased element temperatures, greater mechanical strength, and longer life. They are:

Round Rod	*Flat Ribbon*
246.35 ft. of No. 2 wire	107.95 ft. of 1-in. × 0.0253-in. ribbon
	133.6 ft. of ¾-in. × 0.04-in. ribbon.

CONCLUSION

The derivation of fundamental equations for use in the design of electric heating elements has shown what are the physical limitations of the problem. As a sequel thereto, it has been found that one of the earliest rules-of-thumb gives good factors of safety at all electric furnace temperatures.

Abridgment of

Application of Induction Regulators To Distribution Networks

BY E. R. WOLFERT[1] and T. J. BROSNAN[1]

Non-member Associate, A. I. E. E.

Synopsis.—This paper considers, in a general way, the application of automatic induction voltage regulators to network distribution systems. A discussion of the usual methods of applying both single and three-phase induction regulators is given, and their relative merits considered. The latter part of the paper takes up various methods that may be used to obtain successful operation when automatic induction regulators are operated on parallel feeders.

About 80 per cent of the companies now having network systems in operation use induction regulators to control the voltage of the network and over 75 per cent of these apply separate regulators to the individual feeders rather than regulate the voltage on the bus.

Regulator Application

On a three-phase, three-wire feeder, one three-phase regulator, two single-phase regulators or three single-phase regulators may be employed, while on a three-phase four-wire feeder, either three single-phase or one three-phase regulator may be used. Any of these will give satisfactory voltage conditions at the load if the bus voltage of each phase and the current carried by each line are balanced.

A three-phase regulator is usually connected to a feeder as shown in Fig. 1, and the action of such a regulator is illustrated in Fig. 1A. The triangle *A-B-C* represents the voltage conditions existing at the station bus, while the triangle *X-Y-Z* shows the regulated voltage. It may be seen from this that if the three-phase regulators in the different feeders supplying a network are not made to boost or buck the same amount at all times, an angular voltage displacement is introduced between the corresponding voltages in the different feeders. With the first type of network protectors developed, this angular shift of voltage had the serious effect that it was liable to cause pumping; that is, periodic opening and closing of the network protectors.[2] The possibility of network protectors pumping because of this angular voltage displacement has been eliminated in the latest type of protector by the addition of the phasing relay.[3] The voltage shift, however, still introduces some undesirable system conditions.

The usual connections used for 2 single-phase regulators on a 3-phase feeder are shown in Fig. 2 and their operation is illustrated in Fig. 2A. The phase angle, as well as the magnitude of the voltage in phase *A C* is changed by an unequal movement of the two regulators on the other phases, as is illustrated by the line *X Z*. The angular shift may be avoided by mechanically connecting together the two regulators on the same feeder.

If the feeders supplying the network are connected three-phase, four-wire and three single-phase regulators are used on each feeder, these regulators may be applied

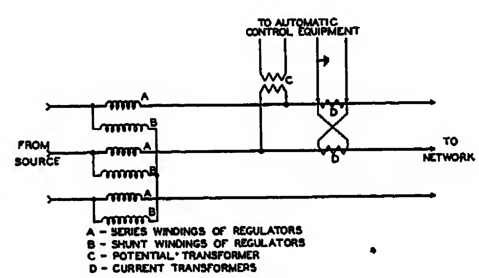

Fig. 1

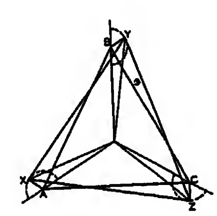

Fig. 1A

Fig. 1 and 1A—Vector and Connection Diagram of Three-Phase Induction Regulator

as shown in Fig. 3. Then, as illustrated in Fig. 3A, the voltages added or subtracted by the action of the regulators are always in phase with their respective line to neutral voltages, and therefore, there is a fixed phase relation between these voltages in the different feeders.

Fig. 4. shows the connections used when three single-phase regulators are used on a three-phase, three-wire system and Fig. 4A depicts the action of the regulators.

A comparison of the relative first costs of the regulators for different feeder sizes has been worked out for each of the arrangements described, and the results are given in the curves of Fig. 5. In each case the line

1. Both of the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

2. W. R. Bullard, *Operating Requirements of the Automatic Network Relay*, A. I. E. E. Trans., Vol. XLV, 1926, p. 1203.

3. J. S. Parsons, "The Network Relay," *Electrical Journal*, December 1927.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

voltage of the feeder has been taken as 4000 and the proper regulators applied to give a regulation of 10 per cent buck or boost.

The losses of each of these combinations of regulators, expressed in percentage, are shown in the four curves in

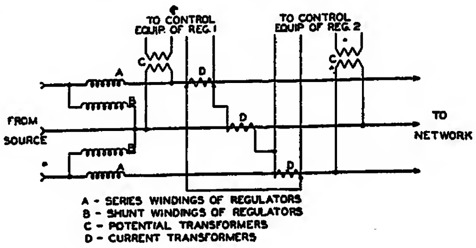

Fig. 2

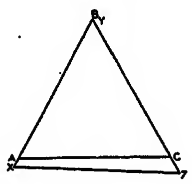

Fig. 2a

Fig. 2 and 2a—Vector and Connection Diagram of Two Single-Phase Induction Regulators on Three-Phase Three-Wire Feeder

Fig. 6. The curve letters used in Fig. 6 refer to the same regulator arrangements as the corresponding curves in Fig. 5.

The use of feeder voltages of 11 kv. and 13.2 kv. has become rather common on a-c automatic network

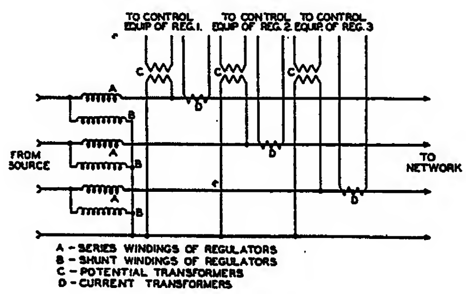

Fig. 3

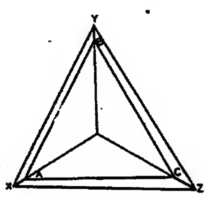

Fig. 3a

Fig. 3 and 3a—Vector and Connection Diagram of Three-Single-Phase Regulators on a Three-Phase Four-Wire Feeder

systems. When regulators are supplied on such feeders, it is possible to use high-voltage regulators connected to the feeder in the usual manner, or to use standard 2.4-kv. regulators with shunt and series transformers.[4]

4. "Regulators for Network Distribution Systems," by E. E. Lehr, *Electric Journal*, July 1925.

The primary windings of the regulators are supplied through the shunt transformers, and the secondary windings of the regulators are connected into the feeder through the series transformers. The question of which type to use is essentially an economic one, and Fig. 7

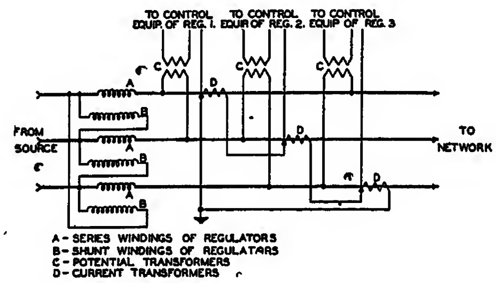

Fig. 4

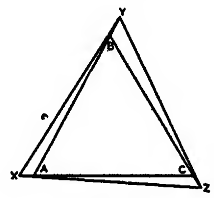

Fig. 4a

Fig. 4 and 4a—Vector and Connection Diagram of Three Single-Phase Regulators on a Three-Phase Three-Wire Feeder

shows the first cost of the two types. The comparison is based on regulator ratings.

Parallel Operation

Fig. 11 clearly illustrates that a closed loop is formed in a network system by the feeders, the station bus, and

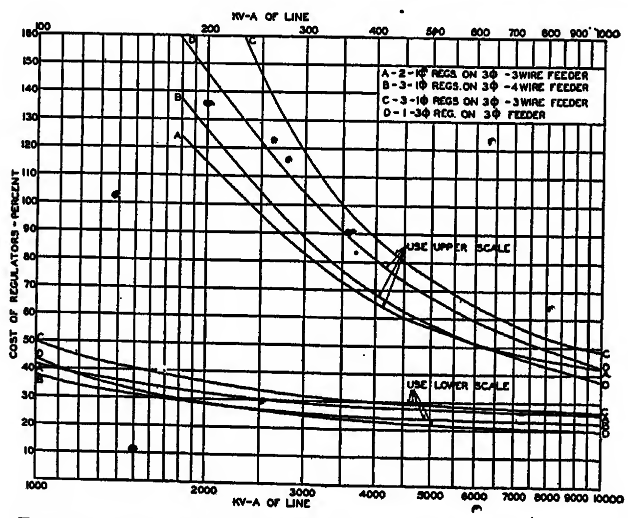

Fig. 5—Cost Comparison Regulators for 4000-Volt Feeders

the secondary system, and a voltage unbalance will tend to set up a circulating current in this loop. The problem of regulation in brief, is to maintain satisfactory voltage at the load, and at the same time prevent unstable operation of the regulators.

The first and most reliable means of operating reg-

ulators in parallel is by mechanical interconnection. It is, however, frequently inconvenient or impossible to mechanically connect them together and in these circumstances it has been considered necessary to use some form of electrical interconnection. Several schemes based on the principle of cross-compensation have been used for this purpose. Their limitation is

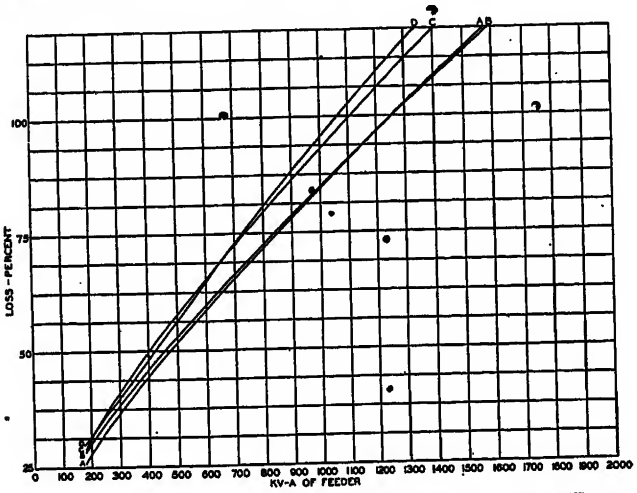

Fig. 6—Loss Comparison Regulators for 4000-Volt Feeders

that they can only be successfully applied to feeders having an appreciable impedance since their sensitivity to circulating currents depends on the settings of the compensators.

A circuit developed to secure sensitivity is shown in Fig. 10. The two current transformers $C\,T_1$ and $C\,T_2$,

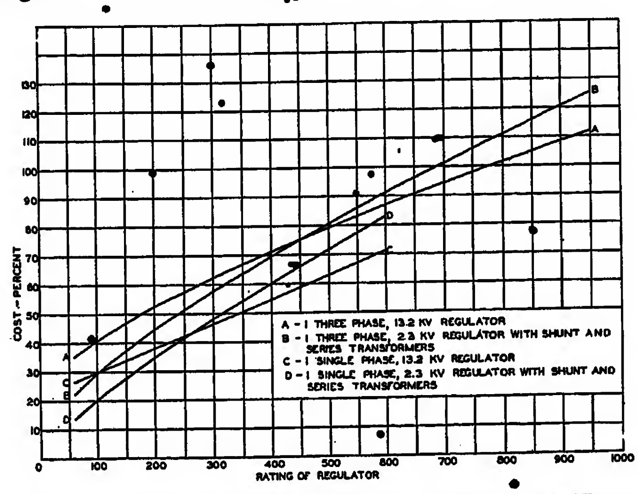

Fig. 7—Cost Comparison Regulators for 13,200-Volt Feeders

on the parallel feeders are connected in series so that when the feeders are carrying the correct portion of the load the secondary current of the current transformers simply circulates between the transformers. If, however, the current in the feeders is unbalanced, twice the unbalanced current will flow through the compensators. These are so connected that a voltage is induced in the primary relay circuit so as to restore normal conditions.

The transformers $C\,T_3$ and $C\,T_4$ supply the current for line-drop compensation in the usual manner. For feeders of low impedance, the current transformer ratios may be chosen so as to give a high compensator setting to secure sufficient sensitivity to circulating current.

Induction regulators are now being applied to networks in many cases, using only the standard method of connection.

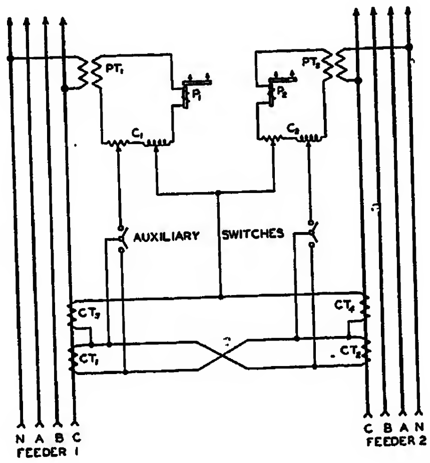

Fig. 10—Circuit for Limiting Circulating Current and Including Line-Drop Compensation

The two regulators shown in Fig. 11 controlling the voltage of the feeders to the network transformers are connected in the standard way. If the compensators of each regulator are set for one-half the loop impedance, the regulator auxiliaries produce no restoring effort when the regulators are displaced from each other an equal amount from the normal position. If one regulator is manually displaced from the normal position

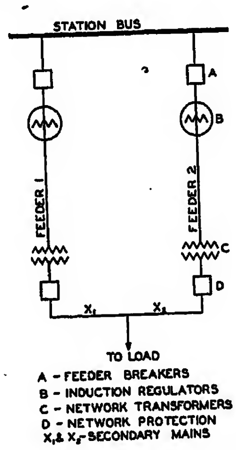

Fig. 11—Single-Line Diagram of Simplified Network System

by X per cent in the boost direction, a circulating current of X divided by Z will flow where Z is the loop impedance in percentage. The voltage which acts on the primary relay of the regulator displaced is the regulated voltage $1 + X$ less the voltage of the compensator, which in this case is (X divided by Z) times (Z divided by 2) and equals (X divided by 2). If the regulator is released at this point, it will return to the

normal position, since the primary relay voltage is higher than normal. However, suppose the regulator is held displaced and the action of regulator No. 2 examined. The primary relay voltage of No. 2 regulator will then be one plus X divided by two and it will start toward the buck position. When it reaches X per cent from the normal position in the buck direction, the circulating current will then be 2 X divided by Z. The primary relay voltage of No. 1 regulator is the normal voltage plus the boosted voltage less the product of the circulating current and the compensator setting. The product of the circulating current and the compensator setting is equal to the boosted voltage, *i. e.*, (2 X divided by Z) times (Z over 2) equals X. In other words, the compensation is equal to the voltage above normal caused by the action of regulator No. 1. Since the voltage of the compensator and the above normal feeder voltage are in opposition in the primary relay circuit, normal voltage is applied to the primary relay and no action takes place. The voltage of No. 2 primary relay is the normal voltage less the voltage below normal plus the compensator voltage. The resultant again gives normal voltage applied to the primary relay.

It should not be noted that if the compensators are set for anything less than one-half the loop impedance, a restoring effort will result as the compensation is less than the voltage above normal caused by regulator No. 1. Thus the primary relay voltage is less than normal and regulator No. 1 will go to full boost position. The opposite action takes place at regulator No. 2 and it will go to full buck position.

Table 1 has been prepared from calculations and shows the load voltage and division of load current for different compensator settings with a concentrated load of 100 per cent at 80 per cent power factor and with X_1 of Fig. 11 equal to zero, and varying values of X_2. The table is based on a reactive circuit neglecting resistance, and the power factors given are based on the load voltage. The location of the load chosen in making up this table represents the most severe condition for obtaining regulator stability.

TABLE I

Compensator setting Per cent	Load voltage Per cent	Current		Power-factor		Reactance		X_2
		FDR. No. 1	FDR. No. 2	FDR. No. 1	FDR. No. 2	FDR. No. 1	FDR. No. 2	
0	96	66.7	33.3	80	80	10	10	10
9	99.5	76.5	27.2	70	98	10	10	10
8	99.0	74.0	28.0	72	95	10	10	10
5	97.7	70.0	30.6	76	87	10	10	10
0	96.4	60.0	40.0	80	80	10	10	5
9	99.5	70.3	33.1	68	97	10	10	5
8	99.1	67.6	34.0	71	94	10	10	5
5	98.0	62.5	37.6	77	85	10	10	5
0	97	50	50	80	80	10	10	0
9	99.7	50	50	80	80	10	10	0
8	99.4	50	50	80	80	10	10	0
5	98.5	50	50	80	80	10	10	0
*	99.6	60	40	80	80	10	10	5

*Compensator feeder No. 1 set at 9 per cent and compensator feeder No. 2 set at 13.5 per cent.

Tests have been made that fully verify all of the results given in the table. Actual operating experience also shows that stable operation of single-phase regulators is obtained and satisfactory voltage maintained in the secondary system if care is taken in setting of the relays and compensators.[5]

The voltage causing circulating current of two three-phase regulators in parallel, one of which has its regulator voltage BY (Fig. 1A) at slightly less than 90 deg. from OB and the other slightly more than 90 deg. from OB, will be approximately in phase with the voltage OB. Also any change in magnitude of the voltage causing circulating current will change the regulated voltage OY, applied to the primary relay, by approximately the same amount.

However, with the two regulators a few degrees apart but in such a position that voltage $B\,Y$ is nearly in phase with $O\,B$, the conditions are entirely different. In this case, although the voltage tending to circulate current may be of the same magnitude as that in the preceding case, it is nearly at right angles to the voltage $O\,B$. Furthermore, a change in magnitude of the voltage causing circulating current has no appreciable effect on the regulated voltage applied to the primary relay.

Thus the voltage tending to set up a circulating current and, therefore, the circulating current itself can have a phase relation from practically zero to 180 deg. with voltage $O\,B$. Consequently, satisfactory operation of three-phase regulators in parallel using standard connections may be obtained only when the loop impedance is comparatively high.

The use of electrical interconnection becomes difficult when three-phase regulators are used because of the varying phase relation of the voltage causing circulating current. Mechanical interconnection of the regulators on the different feeders, however, will prove entirely satisfactory.

Summarizing, the type of induction regulators to be applied to network feeders depends largely on the network and feeder characteristics. The feeders and network forming the loop between the regulators may be classed as low, moderate, and high impedance. It is desirable to interconnect mechanically both single- and three-phase regulators on low-impedance loops. If single-phase regulators are used on low-impedance loops electrical interconnection as shown in Fig. 10. may be successfully used. On moderate impedance loops single-phase regulators may usually be successfully operated without any interconnection while three-phase regulators should be mechanically interconnected. Either single-phase or three-phase regulators will operate satisfactorily on a high-impedance loop using the standard operating control circuit.

5. *Operating Experience with the Low-Voltage a-c Network in Cincinnati*, by F. E. Pinckard, A. I. E. E. Quarterly TRANS., Vol. 47, July 1929.

Protective Devices

ANNUAL REPORT OF COMMITTEE ON PROTECTIVE DEVICES*

To the Board of Directors:

The work of the Committee this year has been; first, the revision of present and preparation of new standards; second, a survey and review of research and development made during the past year in the several fields covered by the Committee; and third, arranging for the preparation of papers for presentation before meetings of the Institute.

The work of the Committee, as organized at the meeting in New York in November 1928, has been carried out by subcommittees, each under the direction of its own chairman. The fields covered and the chairmen in charge of the subcommittees are as follows:

Lightning Arresters	Herman Halperin	Commonwealth Edison Company, Chicago, Ill.
Industrial Equipment and Service Protection	R. C. Muir	General Electric Company, Schenectady, N.Y.
Current Limiting Reactors	N. L. Pollard	Public Service Production Company, Newark, N.J.
Oil Circuit Breakers, Switches, and Fuses	A. M. Rossman	Sargent & Lundy, Chicago, Ill.
Relays	H. P. Sleeper	Public Service Electric and Gas Company, Newark, N. J.

The Subcommittee on Communication Line Protection which reported last year has been discontinued as it was felt its work overlapped with that of the Technical Committee on Communication Lines.

SUBCOMMITTEE ON LIGHTNING ARRESTERS

Work has been continued on the A. I. E. E. Standards for Lightning Arresters. Two preliminary reports of these standards have already been published, (one in 1926 and the other in 1928), under the title *Report on Standards for Lightning Arresters and Other Apparatus for Protection Against Abnormal Transient Voltages.* Because of the wide variation in requirements and practises of arresters for all types of circuits, in the present revision the standards may be limited in scope to arresters for power circuits and the title shortened to *Standards for Lightning Arresters.* As soon as it is practicable, the subcommittee hopes to turn its attention to standards for arresters for other applications and to standards for other protective devices, such as surge absorbers, choke coils, ground wires, fused grading shields, etc.

*COMMITTEE ON PROTECTIVE DEVICES:

E. A. Hester, Chairman,
Raymond Bailey, Vice-Chairman
V. J. Brain, Secretary

A. C. Cummins,	F. C. Hanker,	R. C. Muir,
E. W. Dillard,	F. L. Hunt,	N. L. Pollard,
H. W. Drake,	B. G. Jamieson,	A. M. Rossman,
W. S. Edsall,	J. Allen Johnson,	A. H. Schirmer,
L. E. Frost,	S. M. Jones,	H. P. Sleeper,
E. E. George,	R. L. Kingsland,	R. M. Spurck,
James S. Hagan,	M. G. Lloyd,	E. R. Stauffacher,
H. Halperin,	J. B. MacNeill,	H. R. Summerhayes.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Printed complete herein.

Research on lightning has been continued in the field and laboratory by the manufacturers, in several instances, in cooperation with a number of the operating companies. Extensive tests have been made on the transmission, reflection, attenuation and effect on terminal apparatus of surges applied on full-sized transmission lines. These tests are being continued and are being correlated with the effects of natural lightning on the same or similar lines.

Further studies of natural lightning on transmission lines by the cathode ray oscillograph will be continued during the present lightning season, so that several records of great value and interest may be expected this year as a result of the extensive program. Investigations of surges, their effect on apparatus and dimunition by arresters has been greatly aided by continued development in portability, ease of manipulation and automatic timing features of cathode ray oscillographs. A new type which appears to have many good features has been developed by R. E. George of Purdue University.

A large scale and detailed program of investigation is still being actively pursued by one of the large operating companies on the causes of transformer failures on 4-kv. distribution circuits and their 115/230-volt secondaries during lightning storms and on the possible methods of reducing the number of service interruptions due to such failures. Studies are being made of the effects of resistance in the arrester ground, and laboratory and field tests are being made on the effect and practicability of lightning arrester protection on the secondary side of the transformers.

In the field of high-voltage transmission, work has been continued on the use of fuses in connection with grading shields on insulator strings. Recent development indicate the feasibility of using expulsion type fuses as arcing horns at the tower end of the string. These developments indicate a tendency to build lightning arrester characteristics into the insulator string itself and perhaps, in the future other elements will be developed for connection in series with or in shunt with part of the insulator string to accomplish this end.

There are several problems the solution of which will require further tests and study. Some of these are as follows:

1. *Gap-Setting.* The proper setting of gaps in series with arresters depends largely upon the type of arrester and its application. The application must take into consideration the maximum dynamic voltage, which is dependent on such factors as grounded or ungrounded neutral, relaying, arcing grounds, and also whether the plant is steam or hydro.

2. *Ground Resistance.* With the increasing size of power systems, the problem of obtaining good grounds

has become increasingly important. In the case of large stations, the expense of providing adequate grounding facilities is low enough relative to the total station costs involved so as not to be serious from an investment standpoint, but in the case of small stations, tower footings, etc., the cost of securing adequate ground connections may be high enough relative to the total investment to be rather serious.

3. Quantitative ratings with respect to impulse voltage of lightning arresters and apparatus to be protected in order to give greater assurance of protection.

All things considered the subcommittee feels that splendid progress has been made in the study of lightning and in apparatus and methods of mitigating its interference with power transmission. It looks forward with confidence to accelerated progress in protection against lightning in the immediate future.

Several valuable papers have been presented before the Institute on these and allied subjects, among which the following may be mentioned:

A Graphical Theory of Traveling Electric Waves, by V. Karapetoff, A. I. E. E. Quarterly TRANS., Vol.48, April 1929, p. 508.

Progress in Lightning Research in the Field and Laboratory, by F. W. Peek, Jr., A. I. E. E. Quarterly TRANS., Vol. 48, April 1929, p. 436.

1927 Lightning Experience on 132-Kv. Transmission Lines, by Philip Sporn, A. I. E. E. Quarterly TRANS., Vol. 48, April 1929, p. 480.

Theoretical and Field Investigations of Lightning, by C. L. Fortescue, A. L. Atherton, and J. H. Cox, A. I. E. E. Quarterly TRANS., Vol. 48, April 1929, p. 449.

Protection of Transmission Lines from Interruption by Lightning, by 1928 Subcommittee of Power Transmission and Distribution Committee, A. I. E. E. Quarterly TRANS., Vol. 48, April 1929, p. 487.

Rationalization of Transmission System Insulation Strength, by Philip Sporn, A. I. E. E. Quarterly TRANS., Vol. 47, Oct. 1928, p. 998 (Discussion p. 1009).

Relation Between Transmission Line Insulation and Transformer Insulation, by W. W. Lewis, A. I. E. E. Quarterly TRANS., Vol. 47, Oct. 1928, p. 992. (Discussion 1009).

Symposium on Surge Voltage Investigation on Transmission Lines, A. I. E. E. Quarterly TRANS., Vol. 47, Oct. 1928, pp. 1111-1154.

A New Type of Hot Cathode Oscillograph, by R. E. George. Presented at the A. I. E. E. Regional Meeting, Cincinnati, Mar. 20-22, 1929.

Fused Arcing Horns and Grading Rings, by P. B. Stewart, A. I. E. E. JL., May 1929, p. 390.

Investigation of Transmission Lines with Artificial Lightning, by K. B. McEachron and V. E. Goodwin, A. I. E. E. JL., May 1929, p. 382

Lightning Studies of Transformers by the Cathode Ray Oscillograph, by F. F. Brand and K. K. Palueff, A. I. E. E. Regional Meeting, Dallas, Texas, May 7-9, 1929.

SUBCOMMITTEE ON INDUSTRIAL EQUIPMENT AND SERVICE EQUIPMENT

Addition to A. I. E. E. Standards No. 15 (A. E. S. C. C-19) Industrial Control Apparatus has been completed, and will be submitted to the A. I. E. E. Standards Committee for joint action with N. E. M. A.

These additions are considered necessary to the Industrial Control Standards inasmuch as there is no standardized basis of short-time current rating or short-circuit interrupting rating of contactors and consequently information is not available whereby contactors might be properly applied.

A paper dealing with the general development and application of industrial control equipment and protective devices is being prepared under the auspices of this committee. Little has been published on this general subject, particularly with reference to the application of contactors, and it is felt that this paper will be of material assistance to engineers and will stimulate progress along the right lines in industrial equipment and service protection.

SUBCOMMITTEE ON CURRENT-LIMITING REACTORS

Some thought has been given to new standards for current-limiting reactors, but it has not been considered practicable to draw any up at the present time.

Last year's report called attention to the progress being made in the field of oil-insulated reactors. This progress has continued, large oil-immersed reactors having been built during the last year for circuit voltages ranging from 2.3 kv. to 73 kv., and in one instance for as high a circuit voltage as 120 kv. This type of reactor has increased the field of application of current limiting reactors, since it can be designed for higher voltages than the dry type and is particularly adaptable for outdoor service.

In the case of the 120-kv. circuit mentioned above, the reactors are used for sectionalizing the 120-kv., 60-cycle bus of a generating station having a capacity of 375,000 kv-a. Each reactor is rated at 2800 kv-a. and introduces 10 per cent reactance at 75,000 kv-a.

During the past year there has been a considerable increase in the number of dry type reactors installed with a marked increase in the use of reactors for grounding the neutral at generating stations.

Two, and possibly three, papers will be published and presented before the Institute in the near future under the auspices of this committee.

SUBCOMMITTEE ON OIL CIRCUIT BREAKERS, SWITCHES AND FUSES

The preparation of more comprehensive standards for fuses is now under way. It is expected that the preparation of these standards will be greatly facilitated by tests which have been conducted during the past year by several operating companies on fuses rated at voltages from 2.3 to 66 kv. A series of tests have also been conducted on fuses of potential transformers.

Several manufacturers have increased their gen-

erating facilities available for testing oil circuit breakers and have carried out, on a large scale, systematic programs of testing their standard circuit breakers. These tests have resulted in improvements in details and have given an increased knowledge of the safe interrupting capacities of these oil circuit breakers.

Field tests have been extended to include 220-kv. oil circuit breakers, and additional tests are scheduled to be made this year. It is expected that the results of these tests will be published as soon as the tests have been completed and the data available for publication.

Increased interest has also been taken in higher speed oil circuit breakers for use on high-voltage transmission lines to improve stability of operation by the more rapid clearing of faults.

Circuit breakers of extremely high speeds have been developed for electric railway protection. Tripping speeds as high as 0.012 to 0.016 sec. for a d-c. breaker and 0.04 sec. for an a-c. breaker have been obtained.

The past year has shown an increased interest in metal-enclosed switching structures. A number of the manufacturers of switching equipment in this country are now building structures of this type. A 33-kv. structure has been in successful operation for over a year and several others are now being built for this voltage. A 22-kv. structure of the oil filled type, the largest structure of this type to be installed in this country, will handle the entire output of one of the largest power stations in the Middle West. The first section comprising 23 units was placed in service this Spring. Several hundred units of this type have also been installed on 2300-volt circuits.

These structures greatly reduce the hazard to human life because the live parts are inaccessible and because the moving or removable parts may be interlocked to prevent incorrect operations. Most of the structures have been built without disconnecting switches, the oil circuit breaker being disconnected from its connections with the bus bars and circuits by being moved bodily away from its operating positions. This has permitted a very simple system of interlocking with the use of but five or six sturdy parts.

The metal-enclosed design is completely fabricated in the shops of the manufacturer, and the equipment is shipped in a semi-assembled condition. These factors tend to promote standardization of design and eliminate a large amount of field work, both of which should in time be reflected in lower costs of switching structures.

Papers on theory, design, and test of the Deion circuit breaker were presented at the Winter Convention of the Institute. This development appears to be a notable contribution to the circuit breaker art, as it eliminates the use of oil, and while at present confined to relatively low voltages, it is hoped that it will later be found possible to adopt it for use on higher voltages. It is also hoped that this development will stimulate further research which may lead to the discovery and application of other new principles for interrupting power circuits.

Through the efforts of the members of this subcommittee, the following papers have been submitted for presentation before the Institute some time during the coming fall or winter:

A Method of Fuse Testing, by B. M. Jones and E. H. Coxe.

Fuse Tests, by S. Murray Jones, Supplemented by comments on recent oil circuit breaker tests.

Potential Transformer Fuses, by H. P. Sleeper and M. F. Riley.

The Effectiveness of Different Types of Barrier Construction in Switch Houses, by P. H. Adams and B. M. Jones.

Subcommittee on Relays

The feasibility of standardizing the operating characteristic of relays of different manufactueres has been investigated. This refers to the standardization of characteristic relay curves, operating current values of relay indicators, and various other characteristics of relays which are possible of standardization. It is apparent that the subject is one which will require considerable discussion by the members of the Institute before a representative concensus of opinion can be obtained, and as sufficient data are not yet at hand, it will be desirable to continue the work of this group for another year.

A review of protective relay schemes in use at this date indicates that there have been no radical changes in relay practise made in the past few years. However, there have been some new schemes introduced and the trend at the moment is a departure from the old standard schemes and is worthy of note.

The great majority of all relay installations in service at this time on transmission lines is some form of the so-called time differential system whereby selectivity between adjacent breakers is secured by the use of selective time settings. This involves the use of overcurrent and directional overcurrent relays in the same manner as has been used for many years heretofore. This system, of course, has the disadvantage of limiting the number of sectionalizing points in series by reason of the cumulative time settings at the source end. It has the further disadvantage of requiring time settings in excess of instantaneous settings.

To enable instantaneous settings to be used with the resulting increase in stability to power systems and minimizing of damage at the point of fault, there has been a tendency to use increased number of installations of differential schemes of transmission line protection. The series scheme of differential protection of transmission lines,—namely, pilot wire relaying,—has never found much favor in this country, although one operating company reports that it has used this method extensively on its 12-kv. loops out of substations, and the scheme has been quite satisfactory. They have

adopted recently the use of pilot wire protection on 66-kv. lines and installed several hundred thousand feet of such pilot wire last year. Modifications of the pilot wire scheme are becoming more in favor, however, as indicated below. The scheme of parallel differential protection of transmission lines, where one line is balanced against another, is the form most commonly used in this country and its use has increased considerably in the past few years.

At this time there is a very definite trend toward the use of schemes of transmission line protection which have not been named but might be called "independent" schemes. By this is meant schemes of relay protection wherein the protection of one section of line is entirely independent of that on an adjacent section. The pilot wire scheme falls within this category but as indicated above has never been commonly used. The impedance relay is a scheme embodying some of the features of this type of protection, and its application is slowly increasing. It is perhaps the simplest scheme of protection that is available at the moment. One of the most interesting applications of this type of protection is a case where the short-circuit current under certain conditions may be less than the full-load current. Here impedance relays are intended to be used for short-circuit protection, which are normally short-circuited out of service by fault detector relays. The latter are operated either by low voltage or the presence of short-circuit current which cuts in the impedance relays and allows them to operate during fault conditions.

A further and more elaborate scheme of this type is one which is now being used on a small scale and has possibilities for improvement and application in the future. This is a modification of the pilot wire scheme where the pilot wires are replaced by high-frequency oscillations on the transmission wires themselves. Two schemes are in use, one a high or radio frequency scheme, and the other a low or audio frequency scheme, both of which are fundamentally the same in operation. At the present time, auxiliary equipment of considerable cost and size is required at the line terminals to enable this scheme to function properly, and tends to limit its use. However, it is probable that these schemes will be perfected and fundamentally they seem to offer the most promising solution for future protection problems, particularly of the more complicated type. They embody all of the most desirable characteristics of relay protection; namely, high speed of operation, independent settings and no limitations as to numbers of stations in series. It is probable that the future trend of the art will be definitely in the direction of applications of this so-called independent scheme of relaying.

There is a growing tendency toward recognition of the importance of bus protection in high-tension stations. Heretofore, the protection of busses in such stations was considered unnecessary, but the increasing capacities involved, with the resulting seriousness of outages, has urged the use of this type of protection. It usually partakes of the form of series differential protection. For this protection, and also for the protection of transformer banks and rotating machines, the use of ratio differential relays is becoming more common and superseding the old type of differentially connected overcurrent relays.

A scheme for securing overcurrent protection on balanced lines without the use of additional relays has been developed. The high- and low-set directional relays are connected in much the usual manner, except that the balance point is made at the mid-point of an auto current transformer, and the overcurrent element of a high-set relay is connected across the entire winding of the auto, instead of in the balanced circuit. It is obvious that the high-set relay receives line current at all times and is connected to trip both breakers. This of course requires the use of a double-contact directional element on the low-set directional relay.

A new scheme of protecting load ratio control units has been developed, using a restrained overcurrent relay. One winding is connected to the exciting winding of the load ratio control unit. The other winding is connected to the line. The effect is to change the setting of the relay so that a percentage tripping characteristic is obtained.

A scheme for detecting ground faults in apparatus by using a restrained current relay with multiple restraining coils has been developed. These coils are connected to the phase current transformers and the operating coil is energized by the residual current.

Radio differential relays have been applied to bus differential protection and their characteristic used to tend to eliminate incorrect operations due to secondary wiring troubles.

There are also two new types of network relays. One of these is designed to operate on high reverse current at normal voltage and is still very sensitive at short-circuit voltage. The other is for the protection of low-voltage a-c. networks, the feeder transformers of which are connected in delta on the low-voltage side and with the middle tap of one winding brought out to obtain lighting voltage. It is essentially a combination of three relays: (a power directional, an overcurrent and an overvoltage) set to trip quickly on transformer or feeder faults, but not being sensitive to small reversals of power.

Several existing types of relays have been modified and improved to give better operation. The ratio differential relay has been modified for application to the protection of three-winding transformers. The induction type overcurrent relay has been speeded up so that it will operate in approximately three cycles. The residual directional relay has been modified so that it will operate correctly over an extended power-factor range. Various types of condenser devices have been developed for securing potential for relay operation without the use of high-tension potential transformers. The most common of these is in connection with the condenser type high-voltage bushing, but other con-

denser types of devices have been developed for this same purpose.

A paper entitled *New Directional Relay Schemes*, by E. E. George and R. H. Bennett is in preparation and will be presented sometime in the near future. Two other papers are also in preparation for presentation before the Institute, dealing with relay acceptance specifications, and with relay experience.

Education

ANNUAL REPORT OF COMMITTEE ON EDUCATION*

To the Board of Directors:

The continued rapid increase in scientific knowledge and in the diversity and complexity of the engineering applications and the engineering responsibilities, combine to make the four-year engineering program a less and less adequate preparation for effective engineering work.

This situation is not peculiar to the engineering profession. The medical and the legal professions have been confronted by a similar situation and to meet it they are requiring students aspiring to those professions to remain on the college campus for a period of 6 years, and after that to serve an apprenticeship of 6 months or a year as a law clerk or a medical interne.

The study of engineering education conducted by the S. P. E. E. has disclosed the fact that very few teachers or engineers propose to meet the situation by requiring *all* engineering students to remain upon the college campus for a fifth or sixth year. Before increasing the length of the engineering course for all students, the engineering profession first proposes to try out thoroughly an alternative method.

This alternative method is to encourage the comparatively few graduates of the four-year engineering course who are possessed of the requisite interest, ability, and financial means, to continue in residence by enrolling in the Graduate Schools, and to encourage the majority, who will continue to enter at once upon their engineering apprenticeships, to continue their educational efforts in a more systematic manner and to a more definite end than at present.

Of all the possible educational movements in which the Institute Committee on Education might engage, none seemed to the committee to have greater possibilities of advancing the standards of professional attainment and proficiency than this movement to stimulate interest in the systematic continuation of engineering education after college and to make adequate provision for a program of post-college education.

The full development and realization of the great possibilities of post-college education will require the cooperation of the engineering profession with the industries and the colleges, and it seemed to the committee that it could render its most effective service:

1st, by seeking to bring the thought of the Institute membership to bear upon the possibilities and the problems of post-college education and upon the responsibilities of the profession relative to this period of training;

2nd, by seeking to stimulate the local Sections to promote this movement by setting to work to canvass or inventory the post-college needs and the educational facilities of their districts and to coordinate the two;

3rd, by seeking to act as a center through which a knowledge of distinctive and effective developments in the field of post-college education may be made known generally.

The views and the aims of the committee have been stated in a brief article entitled *The Post-College Education of Engineers*, which appeared in the April, 1929 issue of the JOURNAL. In this article it is suggested that the local sections, particularly in the industrial centers in which Colleges of Engineering are located, each appoint a Committee on Education. It is suggested that the function of the section committee on education be to canvass the needs and the wishes of the engineers of the district, particularly the younger engineers, and to make these needs and wishes articulate by bringing them to the attention of the college administrations, or the industrial managements, or the engineering authorities in the district in the form of explicit statements such as the following: We have a group of 20 men who will enroll in a course in differential equations, to meet one evening a week for a year, or 15 men who will enroll in a course in advanced circuit theory, or 30 men who will enroll in a course in engineering economics. What provision can be made to meet the needs of these men?

A fully developed program of post-college education will mean a large and important expansion of the work of the colleges of engineering and will play an important part in the development of engineering teachers. This post-college training will compel and will reward a broader and more thorough training than is common in the teaching ranks today. It will afford greater opportunities to determine the adequacy, the relative importance, and the real significance of the principles and the methods taught to undergraduates. It will make teaching attractive to a wider range of engineers by making it possible for men in teaching to have closer contact with engineering practise.

*COMMITTEE ON EDUCATION:
Edward Bennett, Chairman.

E. W. Allen,	A. B. Gates,	H. S. Osborne,
J. L. Beaver,	W. B. Hartshorne,	A. G. Pierce,
H. W. Buck,	Paul M. Lincoln,	C. S. Ruffner,
V. Bush,	O. E. Magnusson,	W. S. Rugg,
O. J. Ferguson,	W. E. Mitchell,	W. E. Wickenden.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Printed complete herein.

Abridgment of

D-C. Railway Substation for the Chicago Terminal Electrification, Illinois Central Railroad

BY A. M. GARRETT[1]

Associate, A. I. E. E.

Synopsis.—D-c. substations designed to meet the demands of heavy railway terminal service are described in this paper. This d-c energy is furnished at 1500 volts from seven substations located in the Chicago district and owned and operated by the power companies. In addition to 1500-volt supply for traction purposes, 4000/2300-volts alternating current is provided for the railway company's light, power, and signal system.

Approximately 80 per cent of conversion capacity is in synchronous converters and the remainder in mercury rectifiers. Reasons for selecting the latter units are given as well as some of the characteristic features of them.

To meet the rigorous requirements as to voltage and current demands under the agreement with the railway company, the conversion units have a rating of 300 per cent load for one minute.

The synchronous converters are of the field-control type, and in order to hold the d-c. voltage to definite values for any load within the rating of the units, and to maintain the reactive current of the unit within the safe limits, there is provided, common to all the converters in a substation, a counter e. m. f. regulating set, a four-circuit rheostat, and a voltage regulator. High-speed air breakers are used on the d-c. side of the units and all 1500-volt feeders.

Another feature of interest is the use of truck-mounted enclosed switch units on both the high- and low-tension sides of the substation. This type was selected in order to eliminate certain operating hazards which exist with fixed type switching arrangements, and to provide the customary factors of accessibility and maintenance.

In operating experience, the substation equipment has met all expectations, the performance of the synchronous converters and high-speed breakers being exceptional, while confidence in the mercury rectifier not lessened.

Introduction

The purpose of this paper is to describe that group of electrical equipment which comprises the substation, presenting the characteristics of this installation as a type representative of a d-c. application in modern railway practise.

These d-c. substations, owned and operated by the power companies, the Commonwealth Edison Company, and the Public Service Company of Northern Illinois, receive the 60-cycle energy for conversion to direct current from the 12-kv. transmission system of the Commonwealth Edison Company and the 33-kv. transmission system of the Public Service Company.

To meet the exacting demands of heavy railway terminal service, the selection of the various electrical units and the arrangement of them in the substation layout followed along tried and proven lines. Yet consideration was also given to some equipment which, lacking at the time experience in the American field, gave promise of satisfactory adaptation to American practise through experience gained with the equipment in foreign use.

The studies, trial investigations, and test set-ups, made jointly by the engineering staffs of the railway company, the manufacturers, and the power companies, gave a satisfactory solution of the various problems imposed by the standards of service, and these, coupled with the thought and experience of the power companies in furnishing conversion service for so many years to the traction systems of Chicago, were indespensable considerations in the design of the substation, including not only the major converting and switching units, but the elements of connection as well.

1. Engineer of Substations, Commonwealth Edison Company, Chicago Illinois.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

Conversion Units

To furnish converted energy under the current and voltage stipulation necessary to maintain the high rate of acceleration and high schedule speed demanded by the suburban service on this electrified terminal, and to approximate these same duties under extra or congested traffic conditions were the principal requirements that had to be imposed on the conversion units.

Over 80 per cent of the total conversion capacity is developed from 11 units of the rotating type synchronous converters, while the remainder is developed from four units of the stationary type, namely, the mercury converter or rectifier.

The decision to use rectifiers can be assigned to several reasons, principal among them being that this new type had the natural advantage which a unit with no moving parts has over one with rotating parts and wearable and friction surfaces, and that it gave every indication through future development and application of meeting the demands placed upon it by American practise. Other reasons included the generally known advantages of the rectifier—high-efficiency with fluctuating loads, absence of noise and vibration, low maintenance expense, and elimination of extensive ventilation facilities sometimes required with the synchronous converter. Also, in this instance a considerable amount of reserve capacity permitted the installation of a representative number of rectifiers.

Synchronous Converters

The synchronous converters, which are of General Electric manufacture, are furnished in 3000-kw. sizes with a d-c. voltage of 1500. Each outfit consists of two 1500-kw. 750-volt units operating in series. Each converter set is provided with a 3150-kv-a. air-blast transformer, arranged, as stated before, in a compact group by mounting the transformer on the bedplates of the a-c. side of the two machines.

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To meet the stiff voltage regulation required under the agreement with the railway company, which permits a voltage variation within the narrow limits of 1400 to 1550 d-c. volts, together with the high drafts of current drawn by the system during the maximum rush hour, the converters are designed with a rating of 50 per cent overload for two hours, and 300 per cent load for one minute. They are shunt-wound and of the field-controlled type whereby the control of the d-c. voltage is obtained by changing the excitation of the unit and providing regulation by means of the reactive current drawn from the line or converter. Because of the reactive current involved, several limits as to rating were established so that overloading by the reactive current or the load current, or by both, would not exist. As previously stated the useful load output varies from 50 per cent overload for two hours to 300 per cent load for one minute, the corresponding rating for the reactive current output varies from 60 per cent reactive current at no-load to 30 per cent for the 50 per cent overload, and 50 per cent reactive for the 300 per cent load of one-minute duration.

To keep the reactive kv-a. within the prescribed limits, and hold the d-c. voltage to definite values for any load within the rating of the unit, there are provided, common to all the converters in each substation, a counter e. m. f. regulating set, a four circuit rheostat, and a voltage regulator.

In order to maintain normal voltage conditions on the low-tension secondary connections to the rotary at times when there may be low primary or system voltage, or to increase the amount of the secondary voltage during periods of high load, the ratio of transformation between the high and the low side of the transformer may be changed in the ratio of 5 per cent by means of a tapped primary winding that is connected to two oil breakers, one of which provides a normal or 100 per cent voltage on the secondary side and the other connection 105 per cent voltage.

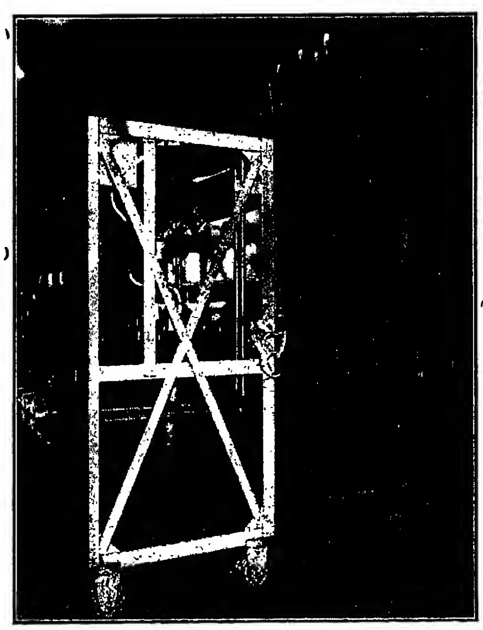
These switch positions are known as the high and the low delta. In addition to this, the transformer is provided with a no-load tap changer on the primary side. Excitation to the converter fields is furnished through a direct-connected exciter operating on the shaft of the low-voltage converter. The exciter provides energy to the shunt fields of both machines at a fixed pressure, and each exciter and the shunt fields of the converters are connected in series to an excitation bus common to all the converter sets in the substation. Also to this bus is connected the d-c. motor of the counter e. m. f. regulating set. This places the motor of the regulating set in series with each exciter and the shunt field of each converter, and by varying the voltage of the motor, the voltage applied to the converter field is likewise changed or controlled. A field rheostat common to both shunt fields is provided and is used chiefly during starting periods or when the regulating set is taken off and the converters are controlled by hand.

The function of the motor-operated four-circuit rheostat and the Tirrill regulator on the d-c. side is to control the operation of the converter and its regulating equipment under both normal and abnormal voltage conditions on the a-c. supply system in conjunction with the load and voltage conditions on the d-c. side of the unit; and to hold the performance of the unit within the prescribed reactive kv-a. limits over the full range of capacity.

Each converter is connected to the 1500-volt d-c. bus through 3000-ampere high-speed circuit breakers of the bucking bar type, located in both the positive and negative leads. The positive breaker, which is located in a metal enclosure on the operating floor, is arranged to trip in case of a reverse current arising either from faults within the unit or on the transmission system. The negative breaker, which is the more active of the two breakers, takes care of overloads or short circuits in the forward direction; that is, those overloads or disturbances occurring on the 1500-volt bus or feeder system.

Mercury Rectifiers

Four of the substations contain mercury rectifiers of the iron tank type. Three of these units operate in



12,000-Volt Enclosed Switch Unit

parallel with the shunt converters described above. Two of the units are of 3000-kw. size, each consisting of two 1000-ampere, 1500-volt rectifiers operated as a single unit. These sets, which are of Brown Boveri manufacture, have separate transformers and underload tap changers, but are connected to a common oil-breaker. The water-cooled rectifier tank is connected to the double six-phase windings of the transformers. This arrangement provides for 12 anodes which are equipped with air-cooled radiators. The water consumption at rated load is approximately one-third gallon

for 100 amperes of load per minute. The units are designed to carry 50 per cent overload for 20 min. and 300 per cent load momentarily. Each bowl or rectifier is provided with an ejector or mercury vapor pump and a single-stage rotary oil pump, both for the evacuation of gases from the interior of the rectifier. The mercury vapor pump, a stationary device, which operates on the injector principle, is actuated by an electric heater located in the base of the pump.

The vacuum, or, conversely, the pressure of gases within the unit, is measured by balancing the gases against a column of mercury known as the McLeod gage. A means of more quickly indentifying conditions within the bowl is obtained by the direct-reading vacuum meter. This device consists essentially of a hot wire gage operating on the Wheatstone bridge principle, arranged so that two of the arms of the bridge are subject to the gas pressure within the rectifier while the other two are exposed to the pressure of the atmosphere.

All seals within the unit are made with mercury,

1500-Volt Switchboard (Truck and Panel Type) 16th Street

asbestos, or by rubber gaskets. The unit is connected to the 1500-volt buses through a high-speed breaker placed in the positive lead of each cylinder.

The air-breakers are interlocked with the oil-breakers so that in case the oil-breaker opens from overload or short circuit, the air-breaker opens also. The rectifier is provided with relay equipment designed to take the unit off the service if excessive temperatures are present within the rectifier cylinder.

The rectifier with the transformers, which are of the oil-filled and self-cooled type, take the ordinary floor construction customarily found in station and substation structures. However, no conservation of space is found with the rectifier, the floor area occupied by the rectifier being equal to that of the synchronous converter. Absolutely no noise of operation is associated with the rectifier proper. Some noise will be found in the rotary pump, but none that cannot be reduced to any desirable degree.

The 1500-kw. rectifiers are of General Electric manufacture, two 500-ampere cylinders operating in parallel from a single transformer and oil breaker. Each cylinder consists of six anodes of graphite composition and are provided with wire-wound heaters to keep the anode insulators at proper temperature during periods of external low temperature and low loads that mercury will not condense on them. The water-cooled chamber is supplied with heaters for the same purpose. To reduce possibility of high transient voltages appearing on the rectifier, condensers in the form of power capacitors are connected to one set of three anodes and across the interphase transformer. That the load will divide equally between the bowls, anode reactors are provided. These rectifiers have practically the same other protective features as the 3000-kw. units, except that following the same design provided for the General Electric converter, high-speed breakers of the bucking bar type are placed in the positive as well as the negative lead of the rectifier. These units have a rating of 50 per cent overload for 20 min. and 300 per cent load momentarily. The inherent regulation of the rectifier is approximately 5 per cent.

Switching Facilities

Another feature of interest in these substations, especially those which are supplied from the 12-kv. system, is the design and arrangement of switching equipment on each side of the conversion units. Fundamentally this consists in having the breakers and disconnecting devices truck mounted and enclosed in metal housing.

The use of the enclosed switch unit is not a new idea, having been on the market in various forms for some considerable time; but its application to both high- and low-tension switching in the same substation is somewhat unusual. The point of principal interest in these installations, however, is the application of the switch unit to certain ideas gained from the operating and engineering experience with other switching arrangements. By means of interlocks, it prevents that kind of operating hazard which seems to be always with us in the old style of fixed bus and switch structure; namely, that of pulling disconnective switches while under load. The switch unit makes readily accessible for maintenance, repairs, and inspection all, of the wearable, adjustable parts. Not only is the factor of safety improved but, because of the accessibility, better maintenance and repair work is done and therefore better performancce is obtained.

Certain operating practises, entirely practical with 600-volt switching equipment, are not acceptable when the pressure has been increased to 1500 volts or above. Correction by isolation, through elevation may not always be desirable, or lack of clearance may render the arrangement impractical; therefore the use of the switch unit with the added advantage of accessibility is in many cases an entirely satisfactory solution. The

advantages accruing to the truck-mounted breaker are considerably lessened when it is necessary to unbolt and, in many cases, untape, the breaker connection from the fixed conductors within the structure. The use of the automatic disconnecting devices for both the current-carrying circuits and the control circuits does away with the unwieldy and, in many instances, dangerous method of manual disconnection. The principle of pressure-contact disconnects can be used in many truck designs so that danger and bother from overheated disconnect switches is appreciably reduced.

By the enclosure of the individual switches in separate metal compartments, the tendency of the arc to spread in case of breakdown is greatly reduced over those cases which have occurred in the open, fixed type of structures. Confining the arc to one or two immediate compartments is quite different from the trouble experienced in the old design where the entire structure and sometimes the room becomes, involved from one breakdown.

The incoming transmission lines, bus-tie connections, and connections to the individual conversion and transforming units within the substation are connected to the 12,000-volt busses through three-phase, 15,000-volt, 600-ampere, type O. E. 6, oil-breaker. The breaker, automatic disconnecting devices and hand-throw disconnecting devices are carried in a panel-mounted truck, the panel serving the double purpose of closing the cell compartment and providing the switchboard facility for all instruments, relays, control switches, and interlocks. The principal features of this type of iron-clad switch gear are that nothing electrical is accessible until the breaker is in the open position, and that when the truck is withdrawn, live parts are shuttered off or set back in protecting recesses. In addition to these features, the switch unit is provided with manually operated knife disconnecting devices which permit all grounding operations to be made through the oil breaker, a practise which has been in force in the substations of the power company for many years. The grounding of any line, bus, or unit directly through cable, clamp, and knife-switch devices means that when the last connection of the circuit is made to a ground source, the operator must be in the immediate proximity of a fault-to-ground should an operating error occur. The simple method of making any set of disconnecting devices used in conjunction with a breaker, double throw, with one side connected to a ground bus, permits the operator to be at a safe distance when the last link in the ground connection is made (the closing of the oil switch) and also provides relay protection should an error exist and live circuits be grounded.

This equipment is arranged so that an oil-breaker can be partially drawn out of the cell for inspection of the parts, at the same time leaving the control intact for operation of the breaker, but cutting off contact with all live high-tension connections. This group of breakers and housings is properly insulated for later installation of a fault bus system should one be found necessary. The high-speed air-breaker connected to the positive lead of the conversion units, as well as all the breakers on the feeders, are truck-mounted and enclosed in metal compartments similar to the switching facilities for the 12,000-volt equipment. The 1500-volt bus is also enclosed in same metal housings. The principle and characteristics of this breaker and its application to the 1500-volt distribution system of the railway terminal have been presented to the Institute by Messrs. Monroe and Allen.[2]

One bay of each substation contains the transformers, regulating, and switching equipment for the a-c. supply to the railway company light, power, and signal systems. Energy is taken off the 12-kv. bus and stepped down to 4000 volts for the three-phase four-wire railway light and power system and the 2300-volt for the single-phase signal system.

Operating Experience

Without exception the synchronous converter has shown a remarkable performance not only in the matter of regulation but under short-circuit conditions in which the number of flashed commutators has been practically negligible. Successful parallel operation with the mercury rectifier has been proved at all ranges of load.

Taking the group of mercury rectifiers as a whole, it cannot be said that our confidence in them has lessened. On the contrary, the operating experience shows that a great number of them could have been installed. For this class of service, it has been demonstrated clearly that the use of one rectifier in a substation, operating as a base load unit with the converters reserved for the peak loads, results in a most satisfactory combination. In some instances a certain amount of trouble on the rectifiers can be charged to an overload condition, as the earlier type lacked capacity comparable with that of the synchronous converter operating in the same substation.

In general, the rectifier under normal operation has shown gratifying results and with recent improvements made upon the unit and its auxiliaries, a reliability practically equal to that of the synchronous converter has been indicated.

The performance of the high-speed breaker has been exceptional, especially in preventing the spread or reflection of short circuits back into the substation.

In agreement with the opinion given of the operating experience of the entire terminal, as expressed in a previous paper, that "From every point of view the equipment has met all expectations and the complete operation has apparently been successful," the operating experience of the substation equipment has indicated a similar result. Troubles have occurred as they naturally do on systems of this magnitude, but in no instance has anything happened that seemed impossible of solution and in most cases, immediate remedies have been found.

2. A. I. E. E. Quarterly Trans., Vol. 47, Oct. 1928, p. 1307.

Radio Interference from Line Insulators

BY ELLIS VAN ATTA[1] and E. L. WHITE[2]

Non-member Associate, A. I. E. E.

Synopsis.—This paper presents a discussion of the causes of radio interference from insulators on high-voltage equipment. The present methods of eliminating this kind of disturbance are explained, and the question of future design is discussed.

Introduction

RADIO broadcasting has brought with it the problem of radio interference. The radio listener is, of course, the one most affected by interference; but the broadcasting companies, the manufacturers of electrical apparatus, and the producers of electrical energy are likewise concerned since the solution of the problem devolves upon them. During the past few years each of these interests has done much to eliminate unnecessary interference; and every kind of equipment used in the supply and consumption of electrical energy has been tried and tested for interfering qualities.

Their experience has shown that radio interference may be classified under five headings, with respect to its origin. These sources are as follows:

1. Consumers' equipment.
2. Low-voltage supply circuits and apparatus (110-550 volts).
3. Intermediate-voltage circuits and equipment (1100-7500 volts).
4. High-voltage equipment (11,000-220,000 volts).
5. Atmospheric disturbances.

Ways have been devised for eliminating practically all radio interference which originates on any of the first three classes of equipment. The last item is obviously beyond human control. The fourth classification includes numerous items of equipment which can be made free from radio interference, and a few other items for which no remedy has been devised as yet. The scope of this paper is limited to the latter group, particularly line insulators of the pin and suspension types.

General

The principles underlying radio interference are similar to those of spark telegraphy and carrier current telephony. In brief, a spark occurring on electrical equipment of any kind sets up a wave train which produces damped oscillations at a multitude of frequencies. The predominating frequencies are the resonant frequencies of the associated lines and equipment, and their harmonics, including those in the radio broadcasting band.

Since the electrical constants which determine the above frequencies are distributed, and several kinds of equipment may be concerned, the resonant peaks are usually broad and overlapping. Consequently a broadcast receiver which has radio interference is usually affected over the entire broadcasting range, with occasional points of greater disturbance.

The extreme sensitiveness of modern receivers, and the use of a-c. supply, make them very susceptible to radio interference. The comparatively small amounts of energy involved in the electrical discharges described later are therefore sufficient to produce a great amount of disturbance in broadcast receivers, particularly when the discharges occur along high-voltage lines.

The distinction between corona and brush discharge should be kept in mind when radio interference from line insulators is considered. Corona discharge usually occurs at lower voltages than brush discharge, and appears as a bluish glow when viewed in a dark room. Brush discharge occurs after corona discharge, and takes the form of fine white streamers. This condition is usually considered as another form of corona discharge, but will be classed separately in this case because of the different interfering characteristics of the two discharges. In a broadcast receiver, corona discharge produces a soft, hissing sound which is not ordinarily objectionable. Brush discharge, however, produces a crackling, frying noise which is very annoying.

Pin-Type Insulators

Corona and brush discharges may occur on high-voltage lines in any or all of the following ways:

1. Between metallic surfaces.
2. Between insulating surfaces.
3. Between metallic surfaces and insulating surfaces.

To entirely free a line of radio interference, all discharges must be stopped. In order to accomplish this purpose, all hardware must be tight; adjacent pieces of hardware must either have sufficient separation to prevent discharges, or must be bonded together; conductors and tie-wires must make perfect electrical contact with the tops of the insulators; and the pins must make perfect electrical contact with the entire surface of the thread in the pin holes. On lines using pin-type insulators these requirements can be met with the exception of the last two. Conductors, tie-wires, and pins do not make good electrical contact with the surfaces of the insulators, and every insulator is therefore a potential source of radio interference.

For the purpose of this discussion, a pin-type insu-

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lator will be considered as the dielectric of a condenser, with the conductor and tie wire acting as one plate and the pin acting as the other. When potential is applied to the plates, a charging current, the magnitude of which is determined by the reactance of the condenser and the applied voltage, will flow into the condenser. Since the reactance of a condenser is a function of its electrostatic capacity and the frequency of the applied voltage, it follows that the charging current is affected by the three factors, voltage, frequency, and capacity.

Consider a 66-kv. pin-type insulator, whose electrostatic capacity is approximately 10 $\mu\mu$f. A charging current of 0.14 milliamperes will flow into it when used on a line operated at a voltage of 38.1 kv. to ground and a frequency of 60 cycles per second. If the conductor, tie-wire, and pin all made perfect electrical contact with the insulating surfaces, this charging current could easily flow into the insulator. Unfortunately, resistance is offered to the flow of charging current by insufficient contact between the wires, pins, and insulating surfaces. Due to the fact that the dielectric strength of air is lower than that of the insulator material, the potential differences at these points of poor contact are sufficient to ionize the adjacent air, with resultant corona and brush discharges.

The problem of radio interference from pin-type insulators is thus reduced to the matter of overcoming resistance to the flow of charging current into the insulator.

Since the magnitude of the charging current into the insulator is determined by the voltage and the frequency applied, and by the electrostatic capacity of the insulator, a reduction in any of these factors will decrease the charging current. In practise, the voltage and frequency are fixed, but the capacity can be reduced by overinsulating the lines. This method has been tried with only partial success, particularly on lines operated at 55 and 66 kv. If larger pin-type insulators are used, the problem of insufficient contact between wire, pin, and insulator is still present.

The best solution of the problem appears to be some method of insuring good contact between the conductors, tie-wires, and insulating surfaces. On existing pin-type insulators, this result can probably be secured by treating the insulator heads and pin-holes in some manner which will eliminate the poor contact between the wires, pins, and insulators.

Metallic paints have been tried, without success, because such paints form a coating of metal particles suspended in varnish and do not offer a good conducting surface. Metal disks, attached to the conductors above the insulators, have proved partially successful, due to the reduction in current density where the conductors and tie-wires contact the insulators. Tests have shown that the same result may be accomplished by looping the tie-wire to form a ring several inches in diameter over the head of the insulator. Tests have also shown that discharges to the heads of insulators are materially reduced by the addition of several extra turns of tie-wire in the insulator grooves. Metal gauze, placed in the tie-wire groove, has proved effective in some cases, and seems to be the best solution of the problem at the present time. Experiments are still being conducted, however, and it is hoped that a compound can be found which will fill in the air spaces between wires and insulators, will be unaffected by weather conditions, and will not be expensive to apply.

The problem of new pin-type insulators is being attacked in several ways. Some manufacturers employ a metal cap cemented on the head of a standard insulator. Another one uses solder-impregnated gauze in the tie-wire groove. Other insulators have layers of metal applied to the heads and the wire grooves. These metals are of various kinds and varying thicknesses. Most of them are too thin to be practical but all have a good contact surface. Still another insulator is treated in the wire grooves and the pin-hole with a special glaze. This last insulator proved to be the best of all when subjected to rated voltage in a comparative test.

Obviously, the use of metal-coated heads and metal caps on pin-type insulators will result in an increase in the electrostatic capacity of such insulators. The charging current will be increased and consequently the current density at the surface of the pin-hole will be increased. Tests have shown that this point is a very important one. It is therefore imperative that the pin-hole be treated in some manner to insure good contact between the pin and the insulator. Metal threads, cemented into the insulator, are being used in most cases, while one insulator is treated with a special glaze, as mentioned before.

At the beginning of this discussion it was stated that corona and brush discharges may occur between insulating surfaces such as the petticoats of pin-type insulators. The presence of such discharges is an indication of faulty design or too high an applied voltage. The remedy is obvious in either case.

Suspension Insulators

Suspension insulators can be classified under three general types, cap-and-pin, link, and spider. The cap-and-pin type, as the name implies, consists of a porcelain disk with a cap cemented to one side, and a pin to the other. Two kinds of hardware are used for attaching adjacent units, the clevis type and the ball-and-socket type. The link type of insulator consists of porcelain disks connected together by loops of metal, so that the porcelain is in compression. The spider type consists of extra-heavy porcelain disks, with the connecting hardware imbedded in both sides in the form of a spider, and secured by a metal alloy instead of cement.

Until recently, suspension insulators as a group have been considered free from radio interference. The potential impressed upon individual disks of a string, as they are used in practise, is comparatively low. On

55-kv. lines, using three units per phase wire, the maximum duty is about 11,000 volts. For 110-kv. lines using six or seven units per string, the maximum potential per unit is 14,000 volts. On 220-kv. lines, using fourteen units per string, the maximum voltage per unit is 23,000 volts without grading rings or shields, and about 15,000 volts with such devices.

When individual ball-and-socket-type insulators are tested in a dark room corona discharge appears at the cap and at the pin when potentials as low as 18,000 volts are applied. Brush discharge occurs at voltages as low as 26,000. This type of insulator, therefore, should not cause interference under ordinary conditions.

Corona and brush discharges also appear on clevis-type insulators at the above voltages when the cotter key is removed from the clevis bolt. With the cotter key in place, and the pointed ends turned upward, brush discharges occur between the points of the key and the innermost petticoat at potentials as low as 11,000 volts. The cotter keys on clevis-type insulators which have been in service on 110-kv. lines for only short periods, show unmistakable evidence of brush discharge, not only from the pointed ends but from the round ends as well. Cotter keys on the units next to the line are affected most, but the keys on other units also show signs of discharge. Obviously the cotter key is at fault on the clevis-type of insulator, and ways of eliminating this source of interference will be taken up later.

Insulators of the link type are even more liable to cause interference than clevis-type insulators. In the older models, no attempt is made to obtain good contact between the links and the porcelain, and brush discharges take place at potentials as low as 2000 volts per unit. When weights are used to simulate line loading, the brush-discharge potential rises to 4000 volts.

The newer models of link-type insulators employ lead shims, soft copper links, etc., in order to get better contact between the metal and the porcelain. Without loading, radio interference starts at 6000 volts per unit. Under 340-lb. tension, interference does not begin until 14,000 volts are impressed. Since the potential across the line unit of a string of six link-type insulators used on a 110-kv. line is about 20,000 volts, interference will be present under those or similar conditions.

On the spider-type of insulator, corona discharge does not start until potentials of 21,000 volts are applied across individual disks. Brush discharge occurs at 26,000 volts. Both discharge points are higher than the corresponding points for either cap-and-pin or link-type insulators, a fact which is accounted for by the heavy mass of porcelain used in this type of insulator, and the absence of sharp points or rough edges at points of high electrostatic flux density.

Both the spider type and the ball-and-socket type of insulator are designed to have certain values of mechanical strength, flashover voltage, and leakage distance, rather than high values of corona or brush discharge voltage. Fortunately these discharge points are higher than the usual operating voltages, and the insulators are satisfactory from the point of view of radio interference.

Clevis-type insulators are also satisfactory when the cotter key is properly designed. One manufacturer has designed a clevis-type insulator in which the cap is recessed to overlap the cotter key and prevent it from turning. One of the large power companies is replacing the regular cotter key with a circular key, so designed that the ends are concealed inside the clevis bolt when in place. Comparative tests show that clevis-type insulators equipped with circular cotter keys are on a par with ball-and-socket insulators.

The link type of insulator is satisfactory if sufficient loading is applied to keep the porcelain and the links in intimate contact, and the voltage per unit does not exceed 14,000 volts. Much of the discussion pertaining to pin-type insulators is also applicable to link-type insulators. The problems involved are similar and can probably be solved by using similar methods.

Many lines using suspension insulators also use arcing horns to protect the insulator disks during flashover and to prevent burning of the conductor. Grading rings, shields, etc., also accomplish this purpose and change the potential distribution along the insulator string, so that the maximum voltage per unit is very much reduced. Tests show that the arcing horn is the only one of the above devices which ordinarily causes radio interference. Brush discharges take place at the ends of the horns, which produce an interference similar in sound to that of pin-type insulators. These discharges can be eliminated in the present design of arcing horn by adding a small metal ball to the end of the horn. The surface area is thus increased, and sharp points are avoided.

Other Sources of Interference

Pin-type and suspension insulators behave alike when subjected to moisture and dirt. The presence of either of these factors will usually increase the amount of interference, particularly on pin-type insulators. Tests in the laboratory show differences of 50 per cent or more in interference caused by insulators when dirty and the same insulators when cleaned. Moisture has a similar effect as shown by the curves of Fig. 1 where the noise level is three times as high for a line with insulators wet as it is for the same line when dry.

Defective, cracked, and broken insulators of either kind set up a disturbance which often affects radio receiving sets several miles away. Small projections on the surface of the porcelain sometimes create interference, especially when they are located in a heavy electrostatic field. Discharges frequently occur from the ends of tie-wires which are not bent closely enough to the conductor.

The remedy in each case is clear. Defective insulators must be replaced. Dirty insulators can be cleaned.

Wet-weather conditions are sometimes minimized by overinsulation, and tie-wire ends should always be bent back as closely to the conductor as possible. Proper inspection and maintenance are therefore essential to the elimination of radio interference from high-voltage lines.

Curves

The curves in Fig. 1 are intended to show the effect of attenuation on radio interference which is being propagated along a transmission line, to give an idea of

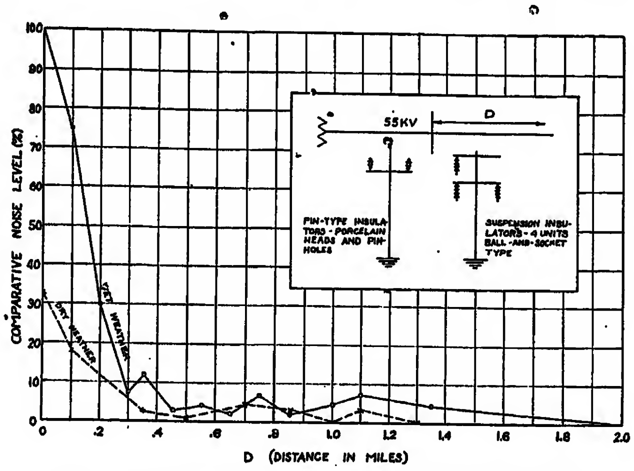

Fig. 1—Attenuation of Interference Along a Transmission Line

the distances to which interference will travel before it is reduced to a non-interfering level, and to show the effect of overinsulation. The observations were made on a 55-kv. line, one mile of which is constructed with pin-type insulators, and the remainder, about 20 miles, with ball-and-socket type suspension insulators.

The origin of the curves is taken at the point where the two types of construction join and the abscissas are measured from that point along the section using suspension insulators. The ordinates are measured by means of a milliameter coupled to the output circuit of a superheterodyne receiver through a transformer. Although the readings of this meter have no absolute value, their significance becomes apparent when it is known that signals from a 5000-watt radio broadcasting station 75 miles away could not be heard with noise levels of ten per cent or more. At ten per cent the signals were about equal in intensity to the interfering noise. At five per cent the signals were stronger than the interference. With a zero-reading on the meter the interference was not objectionable, although it could still be heard along with the signals from the broadcasting station.

The readings for the upper curve were taken during a rain-storm. The lower curve was taken about thirty minutes after the storm ceased. In the case of the upper curve, a slight amount of interference could still be heard at a distance of four miles, which was attributed to the effect of rain on the suspension insulators.

The curves of Fig. 2 are similar to those of Fig. 1. These curves show the attenuation of radio interference at right-angles to a 55-kv. line for two conditions, (1) with no distribution circuits to radiate the disturbance, and (2) with distribution circuits paralleling the 55-kv. line and connected to other circuits at right-angles to the 55-kv. line. The latter condition is one which occurs frequently in cities and towns, but no way of overcoming it has been devised yet. The most effective method of minimizing this kind of radio interference is the elimination of the interference at its source. In many cases, however, the cheapest remedy for the situation may be the use of radio-frequency choke coils inserted in the distribution circuits where they leave the high-voltage line. Standard lightning-arrester choke coils have been tried, but were not successful because their inductance is too low. One company is successfully preventing radio interference on high-tension lines from following its telephone circuits by inserting choke coils in the telephone leads at points where they leave the high-voltage lines. Another company is experimenting with carrier current choke coils, and still another one is trying specially constructed choke coils of about 0.5 millihenry inductance. No reports are available on these tests, however.

Conclusions

Radio interference is one of the problems which must be considered in future insulator designs. On pin-type

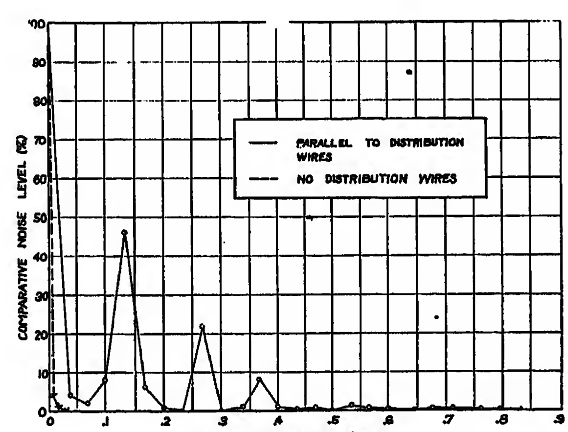

Fig. 2—Attenuation of Interference Perpendicular to a Transmission Line

insulators, corona and brush discharges can be eliminated by proper design of the petticoats, by using metal-coated or metal-capped heads, by using metallic threads in the pin-holes, and in some cases, by using a special glaze on the head and in the pin-hole. Suspension insulators can be improved by changing the design of the cotter key in the clevis type, by eliminating discharges between the links and the porcelain in the link type, and by redesigning all arcing horns to eliminate discharges at the ends. The corona-discharge point on cap-and-pin insulators can be raised by proper

design of hardware, by elimination of sharp points, by insuring adequate clearances at the cap and the pin, and by making the shape of the porcelain conform more closely to the lines of electrostatic flux.

Existing pin-type insulators present the most difficult problem of all. Copper mesh placed under the tie-wires has proved fairly successful in eliminating discharges at the head of the insulator, but experiments are still being made to discover a process which can be easily applied, is not too expensive, and which will stand up under operating conditions during the life of the insulator.

Radio interference from line insulators will always be a problem, because corona and brush discharges occur so readily on high-voltage equipment. Much work has been done to minimize this type of disturbance, and more is contemplated. Adequate maintenance and good construction are essential to the solution of the problem, but the greatest needs are for improved designs and continued experimenting.

Motor Control for Wind Tunnel

Precision Speed Regulation for the Wind-Tunnel Motor at California Institute of Technology

BY WILLIAM A. LEWIS[1]

Associate, A. I. E. E.

Synopsis.—A wind tunnel for testing model airplanes and their parts requires accurate control of the air velocity. This paper describes a tunnel having electric drive for producing the air movement and explains a system of control, which allows a wide range of speeds and holds the speed very constant at any set value. Either hand or automatic regulation may be employed. The hand control is used for fairly constant speed while the automatic control gives very close regulation.

Introduction

The widespread interest in aviation developed during the last few years has resulted in a large increase in the facilities both for teaching aeronautics and for carrying on further investigations in this field. Under the terms of a grant from the Daniel Guggenheim Fund for the Promotion of Aeronautics, a graduate school of aeronautics was recently established at the California Institute of Technology. One of the principal features of the laboratory, built for the purpose of carrying on the experimental work in this department, is a high-speed wind tunnel with a working section ten feet in diameter. The propeller which forces the air through the tunnel is electrically driven, and the equipment and its control present several interesting features, which will be described in this paper.

Wind Tunnels

Before proceeding to a discussion of the drive, a general description of the tunnel and its use would be desirable. Wind tunnels are used for testing model airfoil sections and new plane designs to determine performance, in the case of planes particularly with regard to taking off and landing. The model to be tested is supported in the center of the working section, usually in an inverted position, and when a stream of air passes the model, the relative motion of air and model simulate flying conditions. The model is supported by wires attached at three points and is held in position by the wires and a series of counterweights. The supporting wires are attached to a set of balances either directly or, as in this case, through a subframe. The reactions of the model may be separated into two components, a force downstream or drag, and an upward force or lift. Since the model is inverted, the upward force with respect to the model is downward with respect to the balances. These forces are instantly felt at the balances and can be computed from the balance readings. The values of the forces together with the temperature, pressure, and velocity of the air, are the data for determining the performance of the model.

This tunnel is of the closed-circuit type, the same air being recirculated. A longitudinal section is shown in Fig. 1. The tunnel occupies a height of nearly four floors, the over-all vertical dimension being about 45 ft. It consists of sections of circular cylinders and cones, connected end-to-end to form the closed circuit shown in the illustration. The four sections in the observation room are made of redwood staves held together by hoops of steel rod and angle iron on the outside. If desired, one or more of the sections may be removed and the tunnel operated with open throat, the circuit being closed by the observation room itself. The remainder of the tunnel is made of reinforced concrete, the interior surface of which was formed by the Gunnite spraying process. At the intersections of the vertical and horizontal sections a series of deflecting vanes

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changes the direction of the wind with minimum loss of energy. The completed vane installation in the lower 20-ft. intersection is shown in Fig. 2. The vanes in the two left-hand corners are arranged so that at a future date, cooling water may be circulated through them to assist in cooling the air in the tunnel. The entire tunnel is supported on its own foundation free from the building, to minimize transmission of vibration.

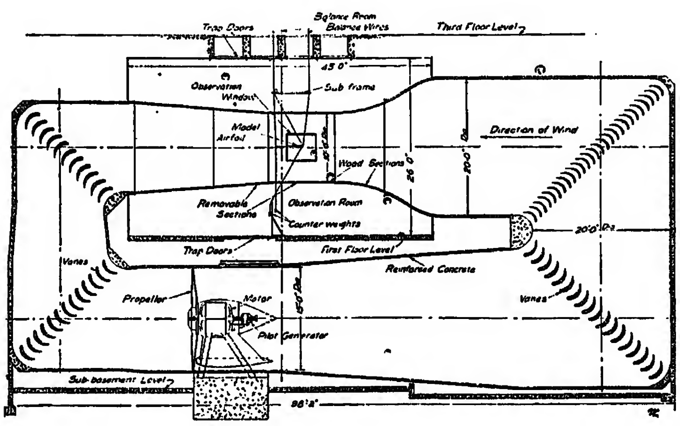

Fig. 1—Longitudinal Section of the Wind Tunnel (Vertical Plane)

Wind Velocity Requirements

For preliminary work it is desirable to control the velocity of the wind from the observation room, but for accurate testing the performance is determined entirely from the balance readings so that the balance operator must have instant and accurate control over the propeller speed. Because of the many variables involved, engineering accuracy requires that the variation in each, particularly wind speed, be kept as small as possible. The maximum allowable variation in propeller speed for satisfactory operation is $\pm$ 0.25 per cent. At the same time, in order to make a complete series of tests it is necessary that the air speed be adjustable over a wide range.

To fulfill these requirements the equipment described below was designed and installed. With it, any wind velocity past the model from a slight breeze produced by a propeller speed of only about 40 rev. per min. to a cyclone of approximately 200 mi. per hr. at a propeller speed of 850 rev. per min., can be easily obtained by operating a single control, located at any point desired. Within the range from 130 to 850 rev. per min. the speed control can be transferred to a regulator which will maintain the speed constant with a very high degree of accuracy. This range corresponds to air velocities of 10 to 200 mi. per hr. By adjusting the positions of a coarse and fine rheostat, one of which is located at each station, the speed held by the regulator may be easily adjusted to any value in its range.

Propeller Motor

The propeller is made with four detachable blades mounted in a central cast hub. The diameter of the propeller is 14 ft. 11 in. and of the tunnel at the section where the propeller is located approximately 15 ft., so that clearance between the propeller and the tunnel wall is very small. After consideration of all advantages and disadvantages, it was decided to place the motor inside the tunnel, supporting it on a structural steel frame extending out through the walls of the tunnel into a heavy concrete base, and to mount the propeller directly on the end of the motor shaft. The obstruction introduced is not serious if the motor and its framework are not too large, since aerodynamical considerations require that the wind stream be contracted just beyond the propeller.

To drive the propeller at the maximum speed requires an input of approximately 750 hp. However, the time for obtaining a set of readings is not great and it was estimated that a machine of 500 hp. continuous capacity with short-time overload ratings, would be satisfactory. The standard machine of this size is equipped with bed-plate and pedestal bearings, and was not well adapted for the type of mounting required. A special design, with bearings mounted in end brackets supported directly from the motor frame, developed for submarine and other transportation purposes, solved the problem. In this way a motor having a completely cylindrical frame and an over-all diameter of only 4 ft. 8 in. was

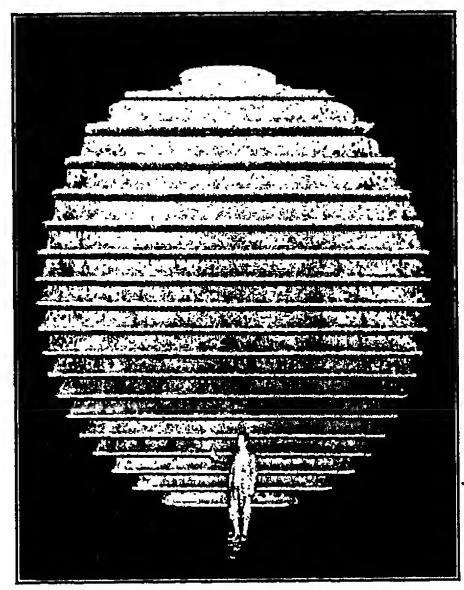

Fig. 2—One of the Lower Deflecting Vane Installations

obtained. The motor, before installation, is shown in Fig. 3. The feet shown in the figure were used for transportation only, it being found that a smaller over-all diameter of motor and covering would result if the feet were eliminated, and the supporting framework made to fit the motor frame. Because of the errors which would be introduced into the speed regulation by vibration, the framework was made very heavy and rigid so that its natural frequency is far higher than any introduced by the propeller. A semi-cylindrical

steel-plate cradle fits the lower half of the motor frame and is bolted directly to the motor. Four heavy H-section columns form the supporting legs and are riveted to the cradle. In assembling, the heavily reinforced concrete base for the framework was first cast complete, with the exception of four pockets for the legs. The legs were then inserted in these pockets, and

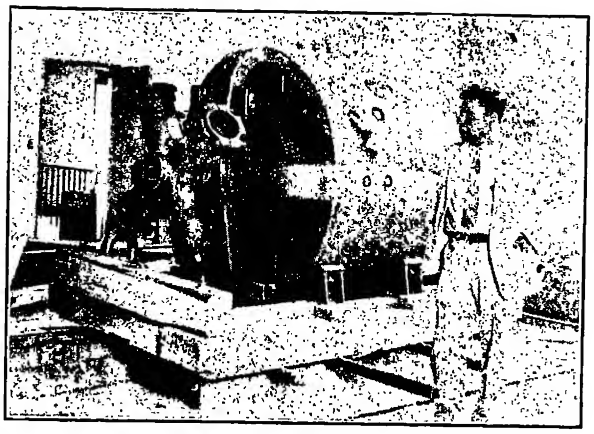

FIG. 3—PROPELLER MOTOR, 500 HP. CONTINUOUS RATING

the cradle riveted to the legs. Next the motor was mounted, the entire structure alined as a unit, and the pockets filled with concrete to unite the framework and base into a continuous whole. The U-shaped pockets in the rear H-section legs were covered with steel plates and used for wiring gutters, cored ducts in the concrete base forming a continuation of these gutters to accessible locations. The details of the structure can be seen in Figs. 4 and 5.

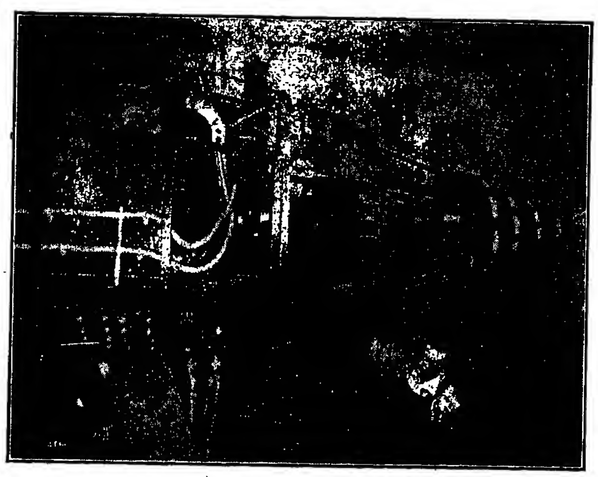

FIG. 4—PROPELLER MOTOR AND PILOT GENERATOR MOUNTED IN THE TUNNEL AND PARTLY COVERED BY STREAM LINE FAIRING

COOLING THE MOTOR

One serious problem, introduced by mounting the motor inside the tunnel, is that of securing adequate ventilation and cooling. The entire output of the propeller is eventually converted into heat by friction of the air, and since the air is recirculated, this heat, together with that due to the losses in the motor, will be taken up by the air and walls of the tunnel. As data for determining the heat transfer from the air to the tunnel walls were meager and inaccurate, it was impossible to predict the temperature to which the air would rise or the time required to reach equilibrium. If the tunnel air remained within reasonable temperature limits, it could be used for cooling the motor, but an air temperature much in excess of 50 deg. cent. would make a separate cooling system necessary. Several estimates placed the average air temperature in the tunnel at 45 deg. cent. Because of the expense of external cooling and in view of the difficulty of carrying on work in the observation room when the temperature of the tunnel is excessive, it was felt that use of the tunnel air for motor cooling would be satisfactory. Part of the air from the propeller is deflected through the motor air passages.

In order to keep the friction loss caused by the air

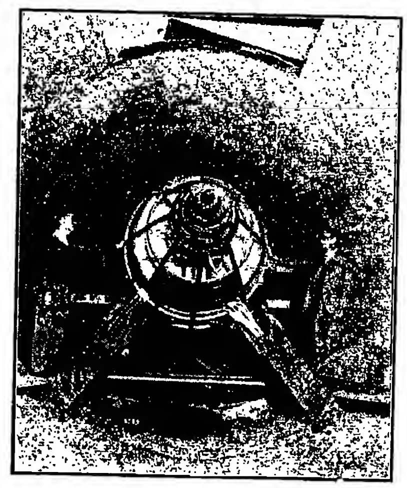

FIG. 5—END VIEW OF MOTOR SHOWING SUPPORTING LEGS USED FOR WIRE GUTTERS

passing outside the motor at a minimum, it was necessary to enclose the motor and its support in a stream line fairing, broad nosed at the propeller end and tapering off to a point at the tail. An opening in the nose and louvres in the sides allow the ventilating air to pass through the motor. In order to keep the pilot generator, (a small generator connected to the main shaft and used with the speed regulator) at as constant a temperature as possible, it is ventilated separately. A baffle inserted between the two machines produces the desired result. A second set of louvres behind the baffle and a third set in the tail provide the necessary cooling air circulation. The fairing is composed of a skeleton framework, Fig. 4, covered with steel plates screwed in place. The section covering the propeller hub revolves with the propeller but the remainder is stationary. To obtain access to any part of the motor it is necessary merely to remove the adjacent plates. An ingenious assembly of the skeleton frame allows a large section of the fairing to be removed as a unit in case of major repairs. Views of the fairing framework with several

of the plates mounted are shown in Figs. 4 and 5. After the fairing of the motor itself had been completed, the legs on each side of the shaft were enclosed in additional fairings. Views of the completed installation are shown in Figs. 6 and 7.

Motor-Generator Set

The propeller motor is a d-c. commutating pole machine, since such a speed range could not be obtained

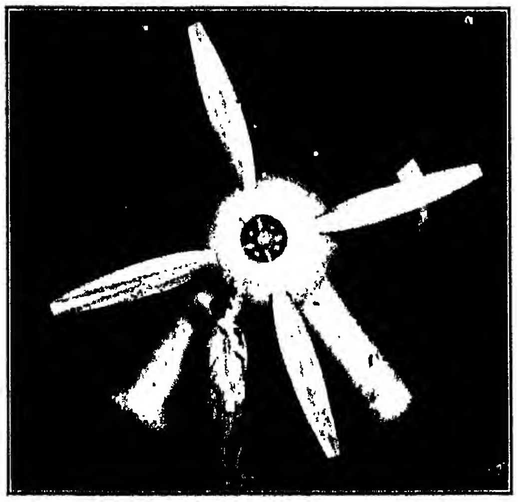

Fig. 6—Propeller End of Main Motor with Fairing Completed

with constant frequency alternating current. For furnishing the direct current and providing a simple means of speed variation, an individual synchronous motor-generator set is provided. In order to make available the maximum possible amount of direct current for physical experiments, the nominal d-c. voltage was established at 230 volts, although the actual voltage varies from residual of the generator up to about 300 volts, depending upon the speed of the propeller motor. Both the synchronous motor and the d-c. generator are provided with direct-connected exciters, separate machines being required because of the speed regulator.

Method of Control

As the motor-generator set had to be located quite close to the propeller motor, because of the large currents involved, it was placed in the sub-basement of the building, just outside the tunnel. The most desirable location for the control station being near the balances in the balance room, five floors above, electrical remote control was adopted for all equipment requiring operation during normal running of the tunnel. Direct current was considered the most suitable for control power, and continuity of service not being absolutely essential, a small induction motor-generator set, giving 125 volts direct current was provided instead of the more expensive storage battery. The former type of control, however, is not absolutely reliable and provision had to be made for disconnecting all the main machines upon failure of control voltage, thus complicating the control circuits considerably.

The apparatus for starting and controlling the a-c. end of the motor-generator set is practically standard automatic equipment and need not be described here. However, since the propeller motor is neither visible nor audible from the point of normal operation and the operators are in general non-electrical men, it was considered worth while to design the entire installation for unattended operation and most of the features common to automatic stations, such as lock-out relay-bearing temperature relays, reverse-phase voltage, current relays, etc., are provided. Also the switching operations of starting are automatically controlled so that the field is applied and the transfer to full voltage is accomplished without the intervention of the operator.

To secure the wide speed range necessary for the propeller motor, the armature voltage or Ward Leonard system of control is necessary. To obtain good efficiency and regulation with this system it is necessary to vary the voltage of the generator which supplies the motor armature. Control is exercised in this case by varying the excitation of the generator either by changing the position of the generator field rheostat or the voltage of the exciter or both. The field of the motor must, of course, be supplied from a separate constant voltage source and in this case was connected to the control generator because the voltages of both direct-connected exciters for the motor-generator set

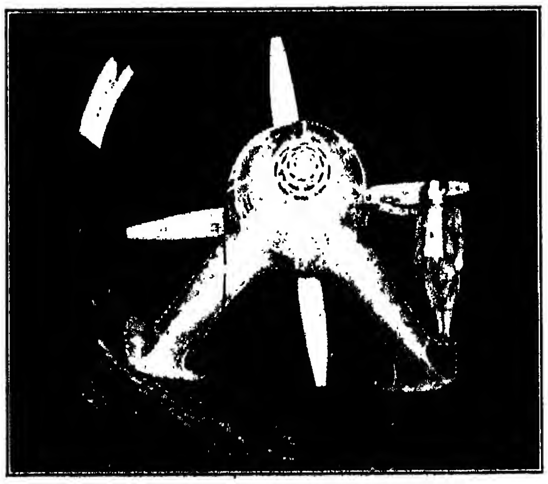

Fig. 7—Down Stream End of Main Motor Showing Completed Installation

are subject to excessive changes. This connection also resulted in the smallest installed auxiliary capacity, since field for the propeller motor is not required until all the large oil circuit breakers have been closed and the closing solenoids deenergized, thus making possible joint use of the same control-generator capacity. The main d-c. connections are shown in Fig. 8, and the armature and field circuits may be easily traced on the diagram. It will be noticed that a series of double-

throw switches are inserted in the armature circuit of the main generator and that the two right-hand switches must be closed in the lower position in order to connect the propeller motor. Under these conditions the differential series field is in circuit, acting to stabilize the speed by opposing a change in current. When the generator is used for other experiments, the differential field may or may not be desired and the third switch allows a choice to be made.

It may also be noticed that no starting resistance is provided in the propeller-motor circuit. The starting current is kept within sufficiently low limits by reducing the generator voltage to its minimum value before closing circuit breaker 172. It is also necessary, of course, that the field circuit be closed before the armature circuit is closed, and that the armature circuit open whenever the field circuit opens. These conditions are obtained by means of suitable interlocks so that circuit breaker 172 cannot be closed until the motor-operated rheostat is "all in," and as soon as the circuit breaker opens, connections not shown in the diagram run the

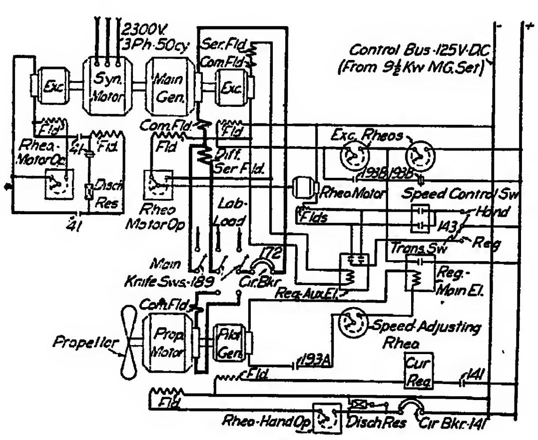

Fig. 8—Schematic D-c. Circuits for Automatic Speed Control and Power Supply

rheostat to this position. The motor is started by operating a single control switch. If the rheostat is in the proper position, the motor starts immediately. If not, the motor will start as soon as the rheostat reaches the "all in" position. The connections are arranged so that field circuit breaker 141 closes first, followed by the closing of circuit breaker 172. When stopping, whether by hand or by one of the protective features, the breakers open in the reverse order. If the field breaker opens for any reason, the armature circuit breaker opens immediately.

After the motor has been started, two types of speed control are available. Under hand control the speed of the motor is brought to the desired value and remains nearly constant due to the inherent regulation of the system, although small variations and a gradual creep in speed, due to temperature effects, occur. However, this type of control is much simpler and is very satisfactory for rough or preliminary work. Under regulated control the speed is set at a given value corresponding to the position of the speed adjusting rheostat, consisting of a coarse and fine section, separately adjustable, and is held at that speed with a high precision by the speed regulator. Although several control stations of both types are provided, only one of each is shown in the diagram. To accommodate additional stations the number of positions of transfer switch 143 is increased, and additional speed adjusting rheostats and relays, 193, are provided for each regulated station and additional speed control switches for each hand control station. For hand control, the entire adjustment is obtained by control of the generator field rheostat, whereas the two elements of the regulator control both the voltage of the exciter and the position of the generator rheostat.

For hand control, transfer switch 143 is closed in the hand position, thus connecting the speed-control switch to a source of power, and the operation of this switch will cause the rheostat to be driven in one direction or the other, thus increasing or decreasing the generator voltage and consequently the speed of the propeller motor. It may be noticed that there are two rheostats in the exciter field circuit, so that the voltage of the exciter is dependent on the position of both rheostats. However, under hand control, relay 193-B is deenergized so that its back contact is closed, short-circuiting the right-hand rheostat, and the exciter voltage is thus determined in this case entirely by the position of the left-hand rheostat. The latter is set at a position which will give normal exciter voltage and is left unchanged, so that the generator rheostat has complete control of the propeller-motor speed.

To obtain regulated control, transfer switch 143 is changed to the "Reg." position. Auxiliary circuits, not shown, immediately run the generator rheostat to the "all in" position, and energize relays 193-B and 193-A. Relay 193-A connects the pilot generator armature to the main element of the speed regulator through the speed adjusting rheostat. Relay 193-B short circuits the left-hand exciter rheostat and inserts the right-hand one in the circuit. The field of the pilot generator is energized through an auxiliary contact of the field circuit breaker 141 and the current regulator, and therefore carries a constant current whenever the propeller motor is running. Under these conditions the voltage generated by the pilot generator is directly proportional to speed. A definite fraction of this voltage, depending upon the position of the speed adjusting rheostat, is impressed upon the main element of the regulator. If this voltage is below the amount required to open the regulator contacts, the contacts close and short-circuit the exciter rheostat. This raises the exciter voltage, hence also the generator voltage, the motor speed, and the pilot generator voltage. If the increase in pilot generator voltage is sufficient, the contacts will open, the exciter voltage will fall and with it, the generator voltage, the propeller motor speed, and the pilot gen-

erator voltage, until the contacts close again. The process repeats continuously. An auxiliary coil and plunger, not shown in the diagram but connected across the exciter terminals, react on the contacts in the same manner as the d-c. coil in an a-c. generator voltage regulator, preventing hunting and keeping the oscillations in speed, produced by the above described opening and closing of contacts, within the most minute limits. Under this condition the mean speed is a function of the position of the speed adjusting rheostat, since the average current in the regulator coil must be a constant and the drop across the rheostat then depends only on its position.

If, in the first instance, the increase in pilot generator voltage was insufficient to open the contacts, the vibrating action does not occur and a speed balance is not obtained. The speed range over which a balance can be obtained with a fixed position of the generator field rheostat is very small, and to increase this range, the auxiliary element of the regulator is provided. If the main contacts remain closed, the exciter voltage will rise above a predetermined value at which one of the contacts of the auxiliary element closes, and this contact changes the position of the generator rheostat until the regulator contacts open, the exciter voltage falls, and the auxiliary contact opens again. Conditions are now satisfactory and the vibrating action of the contacts is immediately set up and a balance obtained. In case the resistance in the speed-adjusting rheostat is reduced, the regulator contacts immediately open, reducing the exciter voltage, the generator voltage, the motor speed, and the pilot generator voltage in turn. If the drop is sufficient, the contacts will close again, a new vibrating action will be set up and a new speed maintained. If the contacts do not close, the exciter voltage will fall so low that the other contact of the auxiliary element will close, increase the resistance in the generator field, reduce the speed of the propeller and finally the pilot generator voltage, until the contacts again close and a new vibrating point is established. Thus, the quick-acting vibrating regulator maintains a precision control over a narrow range and this range is shifted to the proper part of a much broader range by means of the auxiliary element, thus providing a precise speed control over a broad range.

Operating Results

The installation described above is giving entire satisfaction in the operation of the wind tunnel at California Institute of Technology, both with regard to ease of control and accuracy of speed regulation. Although no precision instruments are available for measuring the actual instantaneous variations, observations of an accurate electric tachometer indicate instantaneous variations of less than 0.2 per cent plus or minus, after the regulating equipment has assumed operating temperature, requiring about one half-hour.

There are innumerable causes of instantaneous speed variation, the principal ones being resistance changes due to temperature variations in the armature and field of the propeller motor, main generator and exciters, change in load due to change in angle of attack of the model, change of supply frequency, etc. However, none of these changes can exceed the limit given above of ± 0.2 per cent without bringing about a corrective action from the regulator, so that none of these effects produce any permanent variations or any beyond the stated limits unless they are of such extreme magnitude and so rapid that the regulator is unable to respond and correct them before the limit is reached.

The only causes of permanent variation are those which affect the accuracy of the speed regulator, and include changes in resistance of the regulator circuits and change in permeability of the pilot-generator field with temperature. Such effects cause a gradual increase in speed of approximately 0.25 per cent per hour after operating temperature has been reached, and may be easily corrected for by adjustment of the speed-adjusting rheostat.

As explained above, no permanent speed change is caused by variation in a-c. line voltage or frequency, the changes being immediately corrected for by action of the speed regulator. No data are available regarding the speed of corrective action of the regulator or the amount and rate of change necessary to prevent the regulator keeping the speed within the allowable limits. Although the assembly was developed for a special application, it is composed entirely of standard apparatus and has several features which may be adaptable to other purposes requiring a wide speed range with a high degree of accuracy in speed regulation.

Acknowledgment

The author wishes to acknowledge the kind cooperation of many members of the staff of the California Institute of Technology, especially Mr. L. G. Fenner, Superintendent of Wiring; also of many members of the engineering staffs of the Westinghouse Electric & Manufacturing Company and General Electric Company.

Appendix

Apparatus

Propeller Motor: 500-hp., 230-volt, 700-rev. per min., at full load, shunt connected.

Main Generator: 430-kw., 230-volt, 1000-rev. per min., differential compound.

Main A-C. Motor: 610-hp., 2200-volt, 3-phase synchronous.

M-G Set for Control Supply: 9½-kw., 125 volt, 1500-rev. per min. compound generator; 220-volt, 3-phase induction motor.

Pilot Generator on the Propeller Motor Shaft: Rated 1.5 kw. (but in a larger frame for negligible temperature rise) 600-volt, 700-rev. per min., separately excited.

Automatic Switchboard contains: 3000-ampere automatic circuit breaker, accelerating relays, misc. relays, field contactor, overload relays, annunciator relay.

Speed Control Switchboard contains: Phase balance relay, voltage balance relay, control switches and indicators and regulator operating from the pilot generator.

Much additional apparatus such as exciters and switchboard meters have not been listed in detail.

High-Voltage Low-Current Fuses and Switches

BY ROY WILKINS[1]
Fellow, A. I. E. E.

Synopsis.—For interruption of small currents at relatively high voltages, fuses and air-break switches are most commonly employed. This paper treats of these devices which are suitable for such service as protection on the transmission lines supplying small blocks of power such as rural lines. The requirements for this service are outlined and a discussion is given of the ability of the devices to meet these requirements.

* * * * *

FROM the beginning of the commercial use of electricity one of the problems has been the interrupting of the flow of current in time of need. This is still, after forty or more years, the major problem in the operation of the transmission networks supplying power throughout the world. On its successful accomplishment depends the continuity of electric service so essential to modern life and industry.

In those parts of the transmission network handling large blocks of power, the economic apportioning of cost allows both a high initial capital outlay and a high maintenance cost, and because of its importance demands the best in research and development that the industry affords, resulting in advanced types of circuit breakers and relays to control them.

On the other hand very small blocks of power, found for instance in rural communities, have economic limitations which limit the amount that may be spent and still expect a reasonable return on the investment. They must be supplied by a moderately high-tension line because of the distances covered, and the efficiency of the lines and transformers corresponds within reasonable limits to those on the major circuits. Circuit-interrupting equipment for this class of service is notably deficient if kept within the usual economic limits, particularly so, since the advent of automatic service restoring equipment now in common use on the low-tension side of the transformers used. The greater portion of such installations now are protected on the high-tension side by fuses of various designs and automatic airbreak switches are employed to a smaller extent.

The second important application of high-tension fuses at the present time is for the protection of potential transformers used as metering equipment. Since it has become almost universal practise to sacrifice the transformer when it gets into trouble and depend on the fuse to clear the system from it, the necessity for very low-current fuses has disappeared and the place filled by a fuse having a rating of from five to ten amperes in series with a resistor. For these conditions present day fuses perform reasonably well.

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Fuses

The original circuit-interrupting equipment was simply a reduced section of the conductor which opened the circuit by melting. As the demands increased, various alloys melting at lower temperature than the usual conductor were employed. For the use on high-tension circuits, however, the more durable metals are required for sturdy construction.

The melting curves for ideal conditions follow a logarithmic law, and if the time is short enough or the fuse heat-insulated, as for instance sealed in a vacuum, the law holds quite closely for long fuses. For very short sections a correction for heat transfer to the terminals must be made.

Theoretically there is a definite quantity of heat required to melt a given quantity of each metal to be supplied as watt seconds by $I^2 R$ in the fuse. Practically the various indeterminates, such as conduction and radiation, make the calculation of fusing time for a given fuse on a given current very difficult and generally unsatisfactory, so that various empirical or semi-empirical formulas have been proposed similar for instance to:

$$C = K\, d^{3/2}$$

where C = amperes
K = a constant for each metal and
d = the diameter of the fuse

Such formulas were determined empirically for each fuse for given conditions.

Of the more general formulas in common use those having a factor for the fusing time are the most serviceable, for example:

$$t = \frac{0.262\, \pi^2 d^4 s\, w}{I^2 r_0\, \alpha} \log \frac{1 + \alpha T_m}{1 + \alpha T_r}$$

where t = time in seconds
d = diameter of wire cm.
s = mean value of specific heat of wire in calories per gram per deg. cent. for temperature range
w = density in grams per cu. cm.
I = current in amperes
r_0 = resistivity of wire in ohms per cm.[3]
α = temperature coefficient of wire (average value for temperature range)
T_m = melting point of wire in deg. cent.
T_r = initial temperature.

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Such formulas give approximate values, since no account is taken of latent heat radiation, conduction and the effect of wave form, etc. All values are considered as effective values of uniform sine waves of current and voltage.

It is especially difficult to secure accurate values for the power absorbed by the fuse even with modern oscillographic wattmeters because of phase angle, ratio errors, and inductive effects. Unless exceptional care is taken to eliminate such errors, the records of individual trials of watts may vary as much as 1000 per cent. For the same reasons integration of the current and voltage waves is equally unsatisfactory.

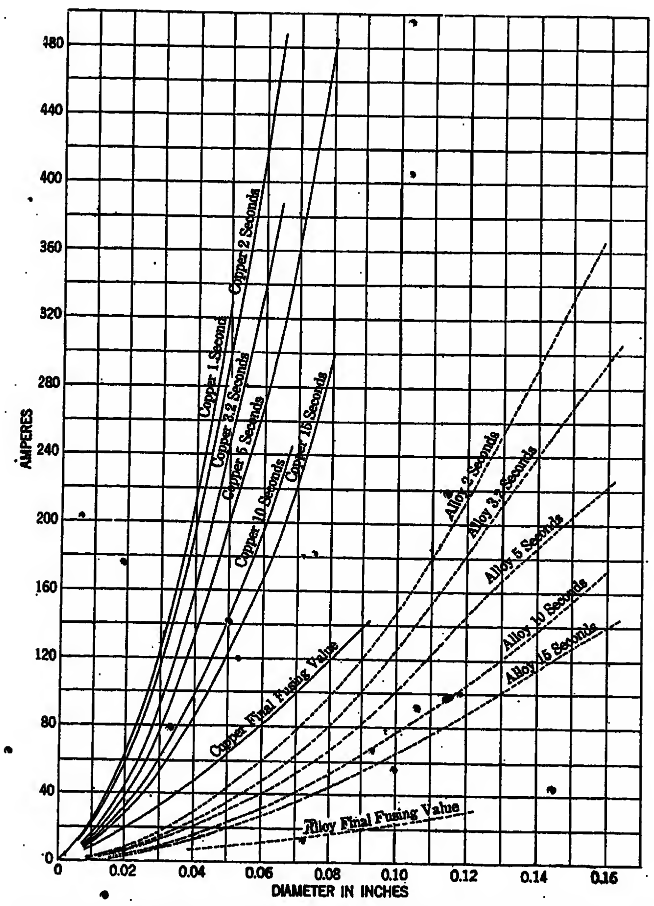

FIG.—1 FUSING CURRENT OF COPPER AND ALLOY FUSES

Comparative data can be secured, however, by averaging a considerable number of trials of each type and the average performance deduced therefrom, as shown in Fig. 1.

In general, if the fuse be tested at low voltage using preferably a good oscillograph and proper control, three or four points plotted on logarithmic paper are sufficient to determine its time-current characteristics. The time clearing characteristics at high voltage, however, do not follow the time fusing curves, since it requires more than the melting of the fuse to clear the circuit, and this time taken up by contact travel or expulsive action is recorded as arc current and is not definitely separated from the true fusing time on the record. The arcing time is moreover dependent upon recovery voltage which is in turn controlled by the connected circuit. The available current is also controlled by the connected circuit and may be many times that required to melt the fuse, frequently volatilizing it directly, whereupon the major portion of the required clearing time is taken up in arcing time.

Since the time of melting is controlled by the size and resistance under control in manufacture, and by the current controlled by the circuit, those fuses having a relatively good conductor of small section such as silver or copper show the most uniform action in service. Silver is particularly desirable since it is not easily corroded under the usual service conditions and the small amount necessary does not form a conducting cloud of vapor such as some of the commoner metals used in low-tension fuses. Nearly all fuses now available have too much metal to be volatilized before they clear, the common expedient of threading a shotgun wad on the element of the expulsion type in order to clear the tube, being a practical demonstration of this fact.

The same limitations which are driving time-current relay settings out of transmission networks in favor of some form of differential or impedance control, operate to limit the success of high-tension fuses for selective clearing of faults. Fuses usually require a far higher current rating on a given installation than the relay setting would be for the same case were it economically possible to use an oil circuit breaker and relays.

The operating requirements of an acceptable fuse may be outlined as follows:

1. Must fuse on a given current in a given time;
2. Must clear circuit under all conditions;
3. Must remain an insulator after clearing.

There might be added desirable requirements calling for the fulfilling of all of the functions of a good relay controlled oil circuit breaker but the above three are fundamental and serve to bar most present day high-tension fuses from being classed as successful when viewed from the user's standpoint.

The present day high-tension fuses may be grouped according to their method of functioning as follows:

1. Plain fusible links
2. Expulsion types
3. Mechanically retracted contacts
4. Explosively propelled contacts.

They all have in common several faults which limit their usefulness. First, the time-current control is very limited; so much so that it is not practical to operate fuses and circuit breakers in series and get selective action where the short-circuit current range is more than two or three to one, because for heavy currents the fuses approach ½-cycle clearing time whereas the relay oil circuit breaker combination have several cycles minimum. The better the fuse as regards its own clearing performance the worse this objection becomes, resulting in a higher rating for a quick acting fuse

for the same duty than for one of the heavier slower acting types.

Practically all fuses now manufactured emit flame and incandescent gas on operation and in addition some types metallic parts and jumpers as well. Few high-tension fuses in commercial use at present are entirely free from this serious objection.

In addition to the above the several types have the following troubles:

Classes one and two above both fail to clear on normal voltage at very slightly above their melting point since the containers, glass, porcelain, or organic material, are all conductors when heated; it follows that if the fuse is gradually heated to incandescence the container will be rendered conducting. Fig. 2 shows examples of such failures. Some rather spectacular results can be expected from either type if the load is gradually increased at normal voltage for several hours and finally allowed to melt the fuse.

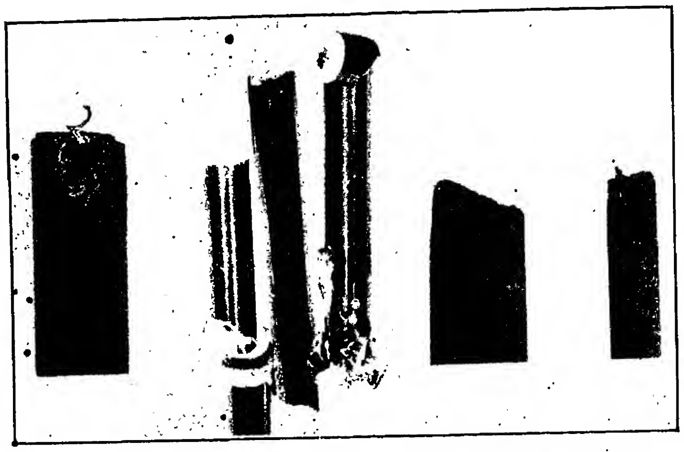

FIG. 2—FUSE CONTAINERS WHICH HAVE BECOME CONDUCTORS BY BEING HEATED

Class three has the primary objection of cost particularly where liquid filled, because of the necessary close supervision in manufacture and careful handling necessary.

They also have to be carefully vented with some form of baffle between the fuse chamber and the liquid in order to prevent shattering the container. In effect this results in an expulsion fuse with a very small chamber and a liquid insulation chamber below.

Under-rating, such as using a 10-ampere fuse in 100-ampere casing, increases the safety but exceeds the economic limit except in very special cases.

In practise considerable care must be exercised in order to prevent liquid leakage either direct or by evaporation.

There are at present very few examples of number four type in service, the so-called shotgun fuse being the best known example. In this type the contact movement is caused by an explosive, usually powder such as is commonly used in fire arms. The fuse itself imbedded in such powder ignites it as soon as either sufficient temperature is reached or an arc is started. The clearing speed is always the same and for this reason the general type is easily adapted to very small fuses at high voltage.

One disadvantage is the necessary clearance required for the exit of flame and contacts.

In application some thought must be given the location of the fuses when blown, a common trouble being to mount them in such a position that when blown in wet weather they will fill with water and thereby become conducting.

AIR BREAK SWITCHES

Because of the lack of available time delay in high-tension fuses and due to the cost of refilling them when blown, many attempts have been made to use automatic air-break switches instead.

The major portion of the air-break switches used for such service are manually closed against a spring or weight and tripped by series overload coils. The tripping is accomplished either direct or through an insulated rod of glass or Bakelite which is used to close a contact on a battery circuit.

The usual clearance between phases is approximately eight feet for 44-kv., and ten feet for 66-kv., and the usual tendency is to carry the arc upward from the insulators rather than across phases.

Practise in automatic air-break switches has demonstrated that the most satisfactory results are secured by moderate speeds, for instance, as the speed usually secured in hand operation from two to four feet per second contact travel.

Compared to high-tension fuses very few automatic air-break switches are in service so that data on their general performance are not readily available.

The same factors which tended in the early days of transmission to force better control of the clearing action and thereby caused development of relays and modern circuit breakers, are operating now to limit the use of the same class of equipment in modern high-voltage distribution lines to those locations where selective clearing action is not essential. For service where overload protection only is desired and moderate interrupting capacity sufficient, present day fuses are reasonably satisfactory.

For higher duties, underrating both in current and voltage minimizes trouble, but is usually not economically feasible.

The building code proposed by the American Welding Society for the construction of buildings has recently been adopted by a large number of Southern and Western cities and has also been recognized by the State of Pennsylvania where the Legislature passed a law making welding available for buildings in first-class cities. The use of welding in the erection of steel frame buildings is increasing very rapidly.

The Interconnected Integraph

BY ROBERT E. GLOVER
Non-member

and

HENRY H. PLUMB
Member, A. I. E. E.

Synopsis.—*A machine for solving differential equations in two variables is described. The equations may be linear or non-linear and may have variable or constant coefficients. The machine draws out the solution in the form of a curve, together with its derivatives. By altering the connections in various ways, a wide variety of equations may be solved with a limited number of integrating and reflexing elements.*

* * * * *

THE occurrence of a number of difficult problems in differential equations with which the writers were required to deal, led them to seek some method of general applicability whereby the solution of such problems might be obtained. Since it was known that a large number of differential equations exist which have no solution in terms of the known functions, success by formal methods seemed hopeless and consideration was given to the possibilities of solution by mechanical means. Working along this line the writers evolved the idea of the interconnected integraph which fulfills the requirements to the extent that it appears to be possible with a moderate amount of equipment to solve a wide variety of ordinary differential equations or parametric equations in three variables. The solution is given by the machine in the form of a graph in Cartesian coordinates, together with similar graphs of its successive derivatives to an order one less than the order of the differential equation. The machine is adapted to the problem at hand by the manner in which the various elements are connected. In order to test out the soundness of the principle, an experimental machine was built which operated as expected. In the article which follows, the order of development will be adhered to, the principle upon which the machine is based being given first, followed by a description of the experimental machine.

The principle upon which the machine operates can be illustrated most clearly by means of an example. For the purpose, let it be assumed that the equation

$$\frac{d\,y}{d\,x} = k\,y$$

is to be solved where x and y have their usual meaning and k is a constant. The wiring diagram for a machine to solve this equation is shown in Fig. 1. At the left is shown in diagrammatic form a d-c. integrating wattmeter element which in this case is to be operated by alternating current. Mounted on the meter shaft is a contactor which closes the platen motor circuit, one or more times each revolution of the meter. The platen motor is fitted with a pawl-and-ratchet device to move the platen a small distance in the direction of its length each time an impulse is received. The platen consists of a non-conducting shell which carries a uniformly spaced winding. This winding interlinks with the flux from an iron core whose primary is energized from an a-c. source. The winding of the platen is symmetrical with respect to its center so that the voltage induced is proportional to the departure of the platen from its mid-position and changes sign when the mid-point is passed. The armature of the meter and the platen primary are connected to a constant potential source and the leads from the platen are connected to the field of the meter. Under these conditions the speed of the meter is proportional to the departure of the platen from its mid-position, and since the construction of the machine insures that the departure of the platen will be proportional to the time integral of the meter speed, we have $\frac{d\,y}{d\,t}$ proportional to y, where y now represents the departure of the platen from its mid-

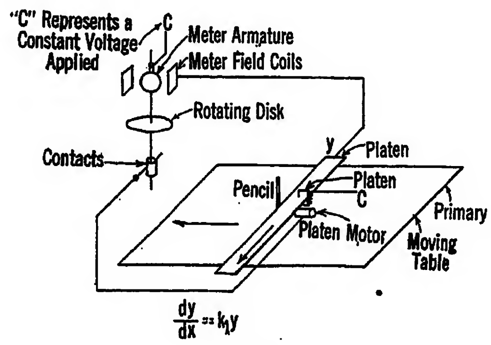

FIG. 1

position. If a pencil is attached to the platen and a table be run beneath it at constant speed in a direction normal to the direction of motion of the platen, the pencil will draw out upon the table a graph of the curve which is a solution of

$$\frac{d\,y}{d\,x} = k\,y$$

where x is measured parallel to the direction of motion of the table. The curve drawn is not smooth, but consists of a series of steps of constant height but varying length. On the experimental machine the height of these steps is about a quarter of an inch. It would be preferable, however, to reduce them to about one-hundredth of the maximum ordinate or to about one-tenth of an inch for a machine of twenty inch span. In figures 2 and 3 are given wiring diagrams for two other representative types of equations. The platens marked X_1, X_2, and X_3 in Fig. 2 and X_4 in Fig. 3 are controlled manually by the operators who cause them to follow graphs of the appropriate functions previously plotted to scale upon the table. In order to simplify

the diagrams, circuits have been represented by a single line.

To carry the example a step further a curve from the experimental machine (connected as in Fig. 1) will be applied to the problem of calculating the relation between barometric pressure and height.

The given data are:

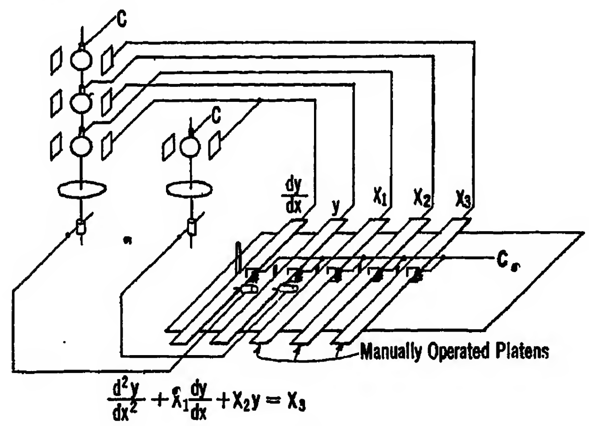

FIG. 2

Weight of one cubic foot of air at 760 mm. pressure and 0 degrees centigrade 0.08072 lb.

Pressure at sea level = 760 mm. of mercury or 2116.35 lb. per sq. ft.

Slope of curve drawn to natural scale by machine with 110 volts on the armature and the platen displaced one inch = $-$ 0.190. Let:

p = pressure in pounds per sq. ft.

h = height in feet

k = weight of one cubic foot of air at deg. cent. and one pound per sq. ft. pressure $= \frac{0.08072}{2116.35}$

Since at constant temperature the weight per cubic foot of a gas is proportional to the pressure, the differential equation which applies in this case is $\frac{d\,p}{d\,h} = -\,k\,p$

Using the curve drawn by the experimental machine, the elements of which are given at the close of the article, let the point where y is 15 inches be chosen to represent conditions at sea level. The scale of p is then determined by the condition that 15 inches must represent 2116.35 pounds per square foot. The scale is then: $\frac{2116.35}{15} = 141.09$ pounds per square foot per inch. The slope of the machine curve at this point is $-$ (0.190) (15) = $-$ 2.85 inches per inch.

For each inch of vertical scale this slope will subtend $\frac{1}{2.85} = 0.3509$ inches on the horizontal scale. The scale of h is then determined by finding how many feet would be required to produce the pressure represented by one inch of vertical scale with air of the density found at sea level. The horizontal scale is therefore: $\frac{141.09}{(0.08072)\ (0.3580)} = 4981$ ft. to the inch. Let it now be required to find the pressure at a height of 3.4 miles above sea level.

$$h = \frac{(3.4)\ (5280)}{(4981)} = 3.604 \text{ in. to scale}$$

From the curve y = 7.77 in.

Therefore p = (7.77) (141.09) = 1096. lb. per sq. ft.

As a check assume a point 8 in. from the axis to represent conditions at sea level.

As before:

$$\text{Scale of } p = \frac{2116.35}{8} = 264.5 \text{ lb. per sq. ft. per inch.}$$

$$\text{Slope at } y = 8. = -\ (0.190)\ (8) = -\ 1.520 \text{ in. per inch}$$

$$\frac{1}{1.520} = 0.6579$$

$$\text{Scale of } h = \frac{264.5}{(0.08072)\ (0.6579)} = 4981. \text{ ft. to the inch.}$$

$\frac{(3.4)\ (5280.)}{4981} = 3.604$ in. From the curve y = 4.08 in.

Then:

$$p = (408)\ (264.5) = 1079. \text{ lb. per sq. ft.}$$

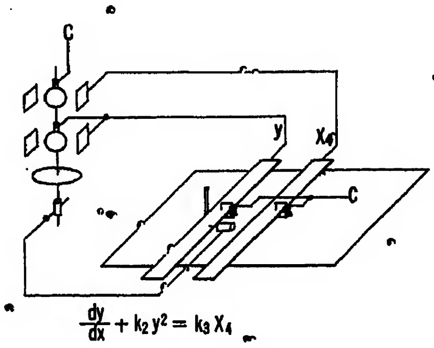

FIG. 3

Checking by formal methods the exact value is found to be 1066 lb. per sq. ft.

DESCRIPTION OF THE MACHINE

A standard d-c. commutator type watthour meter was somewhat modified for this experiment. The 110-volt shunt armature circuit was used without alteration but the series current winding was removed and replaced with a 10-volt shunt winding. The meter was thus made adaptable for integrating the product of two variable voltages; and because there was no iron in the magnetic fields its response should be undistorted when supplied with alternating voltages. The integrated quantities instead of being registered on the customary dials were given effect through a contacting device on the meter shaft to give two contacts per revolution. Studies of periodic functions would

require that the meter reverse its rotation and in order to eliminate frictional effect, a biasing speed of the disk was resorted to, above and below which speed the effects of the meter coils might operate, as long as the bucking effects did not reduce the disk speed to zero. The undesired or extra number of contacts due to the biasing speed were sifted out by the differential gear described later, so that only the registration due to the meter coils alone was finally effective. For the particular problem selected for checking purposes, no periodic functions were involved, however, and this device was not strictly needed. For supplying the biasing speed to the disk, the friction compensator was removed and replaced with a standard type of single-phase induction meter element placed to operate on the damping magnet drag disk. Sufficient load was given to this element to produce an initial disk speed of about 10 revolutions per minute.

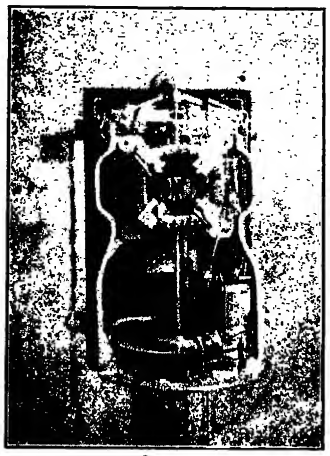

Fig. 4

The second important unit of the integraph was what may be called the platen. This consisted of a transformer core containing an air-gap, with primary winding connected to 115-volt, 60-cycle supply, the secondary or platen winding being wound in a spiral manner to give a smoothly variable voltage from − 10 through zero to 10 volts, the algebraic signs indicating 180 deg. phase difference.

The means was thus provided for supplying a variable voltage from the platen to the field winding of the d-c. watthour meter. The meter contacting device must be interconnected or reflexed upon the platen in such a manner that each impulse accomplishes a slight motion or displacement of the platen. This arrangement whereby each element is controlled by the element which it controls is the characteristic feature of the machine.

The contacting device operated a relay controlling a small motor which furnished the desired motion to the platen by rotating the spool upon which the platen rested at a point near the air-gap. In order to compensate for the number of impulses given out at biasing speed it was necessary to provide a second motion to the platen in the opposite direction from that supplied by the motor. The differential gear arrangement shown in Fig. 5 was worked out so that the two motions could be applied simultaneously to the platen. Any constant speed device could be used for this purpose so long as it was adjusted to exactly neutralize the effect of the biasing speed of the meter. It was therefore taken from the constant speed drive of the moving table. The contacting device necessarily moved the platen by steps while the motion of the moving table gave a uniform restoring motion to the platen. A pencil was attached to the platen in such a way that the motion of the platen was recorded at right angles to the motion of the moving table underneath which carried a paper chart on which the integral curve of the differential equation was automatically drawn. The table was simply drawn along by a constant speed motor operating through a lead screw and a nut fastened to the table, the nut being split for easy resetting of the table.

In order to test the accuracy of the experimental machine an exponential curve was passed through

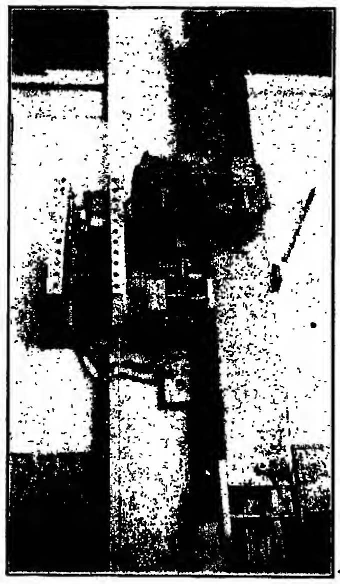

Fig. 5

three points of one of its curves. The comparison for points two inches apart is shown in the following table:

x	$0.190x$	$y = 15.31e^{-0.190x}$	y from the machine curve
0 inches	0.0	15.31 inches	15.31 inches
2 "	0.380	10.46 "	10.40 "
4 "	0.760	7.16 "	7.20 "
6 "	1.140	4.90 "	4.98 "
8 "	1.520	3.35 "	3.39 "
10 "	1.900	2.29 "	2.29 "

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Abridgment of

Instruments and Measurements

ANNUAL REPORT OF COMMITTEE ON INSTRUMENTS AND MEASUREMENTS*

To the Board of Directors:

The Committee on Instruments and Measurements reports activities for the past year as follows:

1. Revision of Electrical Units
2. Measurement of Core Losses in Terms of Sine-Wave Core Losses
3. Distortion Factor—Definition and Method of Measurement
4. Technique of Temperature Measurement.
5. Measurement of Variable Power and Large Blocks of Energy
6. Dielectric Power Loss and Power-Factor Measurements
7. Measurement of Non-Electrical Quantities by Electrical Means
8. High-Frequency Measurements
9. Remote Metering
10. Shielding in Electrical Measurements
11. Papers
12. Conclusion.

Revision of Electrical Units

The progress during the past year of the movement in favor of absolute electrical units in place of those defined by means of arbitrary standards is considered by the Instruments and Measurements Committee to be most gratifying and the actions taken to be epoch making. This progress is recorded in the following report by Dr. H. B. Brooks, Chairman of the Sub-Committee on Revision of Electrical Units.

The resolutions on Revision of Electrical Units which were prepared by the Committee on Instruments and Measurements and transmitted to the Board of Directors, through the Standards Committee, were adopted with a slight change at the meeting of the Board in Denver in June 1928. The resolutions cited the discrepancies existing between the international electrical units and the absolute units they were intended to represent, and called on the United States Bureau of Standards and foreign national standardizing laboratories to undertake the researches necessary to eliminate the discrepancies, and to bring about the legalization of absolute electrical units in place of those defined by means of arbitrary standards. Copies of the resolutions were sent to the appropriate committees of the U. S. Senate and House of Representatives, the Bureau Standards, and to the national standardizing laboratories of England, France, Germany, Japan, and Russia.

To assist in formulating proposals incorporating a consensus of the opinions held in the United States, Dr. G. K. Burgess, Director of the Bureau of Standards, invited a number of organizations to name members of an American Advisory Committee representing the scientific, industrial, and commercial organizations most directly concerned with electrical measurements. These organizations were as follows: National Academy of Sciences, American Institute of Electrical Engineers, American Physical Society, National Electric Light Association, Association of Edison Illuminating Companies, National Electrical Manufacturers Association, and the American Telephone and Telegraph Company. This American Committee met at the Bureau of Standards on June 16, 1928. After due consideration of the information available regarding the present status of electrical measurements, the American Advisory Committee unanimously adopted the following resolutions:

"(1) Resolved, that in the opinion of this Committee, in view of improvements which are being made in absolute measurements, electrical standards should in future be based upon the absolute system of units.

"(2) Resolved, that in the opinion of this Committee, the functions which it is desirable to have the International Bureau of Weights and Measures undertake in connection with the electrical units, are as follows:

> "(1) A central secretariat to arrange for systematic exchange of standards and compilation of results of intercomparisons thus made among the national laboratories.
>
> "(2) A laboratory to which concrete standards representing the results obtained in the different countries may be brought for precise comparisons.
>
> "(3) A repository for international reference and working standards with the necessary equipment so that other standards may be compared with these standards on request."

With the backing of these resolutions, Dr. Burgess attended the first meetings of the (international) Advisory Committee on Electricity, which were held at Sèvres and Paris November 20-22 inclusive, 1928. The timeliness and the importance of the question of the revision of the electrical units are shown by the fact that delegates felt it worth while to come from the far countries of the world, so that the Advisory Committee had a complete attendance of all members. Communications from various countries concerning the electrical units were considered. The cordial spirit and the unselfish aims of the committee are shown

*COMMITTEE ON INSTRUMENTS AND MEASUREMENTS:
Everett S. Lee, Chairman,
H. O. Koenig, Secretary.
E. J. Rutan, Vice-Chairman,

O. J. Bliss,	W. N. Goodwin, Jr.,	W. J. Mowbray,
Perry A. Borden,	F. C. Holtz,	T. E. Penard,
W. M. Bradshaw,	I. F. Kinnard,	R. T. Pierce,
H. B. Brooks,	A. E. Knowlton,	G. A. Sawin,
A. L. Cook,	W. B. Kouwenhoven,	R. W. Sorensen,
Melville Eastham,	E. B. Merriam,	H. M. Turner.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

by the gratifying fact that all the decisions reported were reached unanimously.[1] The committee realized the great importance of dealing adequately with the electrical units, in the light of past experience and present knowledge, and ultimately adopted, by unanimous vote, the following resolutions:

"1. The Advisory Committee on Electricity established by the International Committee of Weights and Measures, considering the great importance of unifying the systems of electrical measurements upon a basis deprived of all arbitrary character, recognizes from the beginning of its first session that the absolute system, derived from the c. g. s. system, may be substituted with advantage for the international system of units for all scientific and industrial determinations and decides to propose its adoption to the International Committee of Weights and Measures.

"2. The Advisory Committee on Electricity, while recognizing fully the great forward steps already taken in the domain of electrical measurements of high precision, does not believe, however, that it is possible immediately to fix with all the necessary and possible accuracy the ratios which exist between the absolute units derived from the c. g. s. system and the international units of current, electromotive force, and resistance, as they were defined by the International Congress at Chicago in 1893 and the London Conference in 1908, and expresses the wish that researches may be carried on toward that end in suitably equipped laboratories, in accordance with a program previously worked out in cooperation with the Advisory Committee on Electricity."

Dr. Burgess was unanimously chosen to report the proceedings of the Advisory Committee to the International Committee of Weights and Measures. The approval of the latter is necessary to put into effect the resolutions of the Advisory Committee. The Committee on Instruments and Measurements regards the action of the Advisory Committee on Electricity as an epoch-making event, and looks forward hopefully to the time when the units of the electrical engineer and those of the mechanical engineer will rest alike upon the fundamental bases, the meter, the kilogram, and the second of time.

Measurement of Core Losses in Terms of Sine-Wave Core Losses

A working committee of the Instruments and Measurements Committee under the chairmanship of Mr. W. M. Bradshaw has been studying for the past year the best way to make core loss measurements on transformers so that they will give accurate "sine-wave" core losses regardless of the wave form employed for excitation. In this connection the working committee issued a questionnaire on the practise of measuring core losses in transformers. This was sent to fourteen known manufacturers of transformers. Replies were received from ten of them. Of the ten replies, five were from manufacturers of power and distribution transformers, all of whom either recognized the necessity for corrections or actually used corrections. The other five were from manufacturers of instrument transformers or special transformers in which core losses need not be measured. Those who only recognized the general necessity for corrections state that they have available a pure sine wave which remains undisturbed.

As a result of the replies to this questionnaire and from the results of their study, the Working Committee recommended desirable procedure in making core loss measurements to the Instruments and Measurements Committee, which recommendations have been regularly transmitted to the Standards Committee. These recommendations provided for the measurement of core loss of transformers preferably with a sine wave of applied voltage; if this is not practicable, the results obtained with a distorted wave of applied voltage shall be corrected to a sine-wave basis by a suitable method.

Three suitable methods, as follows, have been studied and are outlined in detail in the report:

No. 1. Standard Core Method
No. 2. Iron-Loss Voltmeter Method
No. 3. Flux Voltmeter Method

Methods No. 1 and No. 2 use miniature representative sample cores. In Method No. 3 the correct average voltage is applied to the transformer under test irrespective of the wave form of the applied voltage.

The committee recommended preference for methods utilizing average voltage for correcting core loss results to a sine-wave basis to those utilizing sample cores since the sample may not represent correctly the actual transformer under test.

Distortion Factor—Definition and Method of Measurement

A working Committee of the Instruments and Measurements Committee, under the chairmanship of Mr. W. M. Bradshaw, has studied the definition of distortion factor and method of measurement as disclosed in a report of the French Electrotechnical Commission entitled "Methods of Determining the Distortion of the Voltage Wave of Alternators," and have recommended action concerning these, which recommendations the Instruments and Measurements Committee have regularly referred to the Standards Committee. The definition recommended is the same in substance as proposed in the French report, but differs in form to be in agreement with the form of the present A. I. E. E. definition of Deviation Factor, and is as follows:

The distortion factor of a voltage wave is the ratio of the effective value of the residue, after the elimination of the fundamental, to the effective value of the original wave.

1. A full account of the proceedings of the Advisory Committee on Electricity is given in *Revue Générale de l'Electricité* for Dec. 22, 1928.

A general definition to include all periodic waves was recommended as follows:

Distortion factor of a periodic voltage or current wave is the ratio of the effective value of the residue, after the elimination of the fundamental, to the effective value of the original wave.

Details of methods for measuring the distortion factor of a voltage wave were submitted for use in obtaining data for the establishment of suitable limiting values of distortion factor, as follows:

A. Method of Boucherot using an alternator with a sinusoidal wave and a voltmeter.

B. Method of Belfils using a bridge to suppress the fundamental of the wave to be analyzed, and a voltmeter to read the residue.

C. By oscillogram.

D. By harmonic analyzer.

The method (B) seems at the present time to be the most promising, though further study and development of the apparatus are necessary. This work is proceeding.

Technique of Temperature Measurement

The Standards Committee has referred to the Instruments and Measurements Committee the broad question of Standards for the Technique of Temperature Measurement. A subcommittee has been appointed and work is progressing on writing a standard on the technique of temperature measurement. The initial activity will be confined to those temperature measurements included in the present A. I. E. E. Standards.

Measurement of Variable Power and Large Blocks of Energy

The subcommittee on this subject, under the chairmanship of Mr. T. E. Penard, is collecting literature from the various manufacturers of meters and metering equipment relative to this phase of the art. The questions of metering large blocks of d-c. energy requiring the use of large capacity shunts in connection with watthour meters and the calibration of such shunts, as well as the use of several low current shunts in parallel with resistance compensated potential connections, are being studied.

A new oscillating meter clamped directly on the bus bars and working on the stray field produced by the currents in the bus is being studied.

Dielectric Power Loss and Power-Factor Measurements

The Subcommittee on Dielectric Power Loss and Power-Factor Measurements under the chairmanship of Mr. H. C. Koenig has rendered the following report:

In 1928 Messrs. J. A. Scott, H. W. Bousman, and R. R. Benedict presented a paper before the Institute entitled *A Thermal Method of Standardizing Dielectric Power Loss Measuring Equipment,* (A. I. E. E. Quarterly Trans., Vol. 47, July, 1928, p. 819). In this paper the authors pointed out the effect of humidity on an air capacitor. As a result of this paper, at least two new investigations along these lines have been made. In one of them, at the Electrical Testing Laboratories, it was shown that a properly constructed air condenser had a power factor of less than 0.01 per cent over a range of voltage up to 20 kv. per inch between plates, and over a range of humidity up to, at least, 85 per cent in clean air. In the other investigation at the Johns Hopkins University, two successful runs of varying humidity and voltage were made, one at a temperature of 77 deg. fahr. and the other at 85 deg. fahr. No air conduction could be detected up to about 90 per cent humidity. At the time of writing further experiments are still in progress.

In the subcommittee report of 1928, attention was called to the development of standards loads for use in checking dielectric loss equipment. Following the successful application of this standard load rated at 20 kv., a similar load has now been developed for use up to 75 kv. This latter load was also used very successfully in making factory inter-checks of dielectric loss equipment. In general, the results of the inter-comparison of dielectric loss equipments were very satisfactory.

As a result of the inter-check made at various factories two conditions have been noticed which are of interest. (1) It has been noted that while most laboratories are in fair agreement as to power factor measurements, there is a decided lack of agreement on current (and, therefore, watt) determinations. It appears that currents of the order of 1 to 10 milliamperes present a somewhat difficult measurement problem. Most laboratories use the same instruments for watt and current determinations, changing the coil connections and using it as a deflection instrument. The laboratories using a bridge method depend on the capacitance of their reference condenser. One of the most satisfactory methods for measuring these currents appears to be a modification of the transformer bridge. This method requires the use of a potential transformer of known ratio and the accuracy of the method depends only on the potential transformer and the capacitance of a condenser used in making the balance. (2) In a number of cases the condition was encountered where the test plate of the reference air condenser was mounted on insulators in such a way that the field from the high-voltage plate to these insulators terminated on the test plate. This sometimes caused the condensers to have power factors as great as 0.5 per cent. In each case it has been found possible to bring the power factor to zero by guarding and shielding these insulators. This condition is quite noticeable with the large open pedestal type condensers used in many of the cable test laboratories.

During the past months there has been considerable discussion regarding the possible effects of the high-frequency discharges occurring in insulations under high stress on measurements of dielectric loss and power factor. While these high-frequency discharges prob-

ably represent energy losses, it is questionable whether or not any of the present methods of measurements include these losses.

The question of dielectric loss and power factor measurements with particular reference to the shielding of both the measuring equipment and the cables under test will be covered in a symposium to be held at the Summer Convention on Shielding in Electrical Measurements. Two papers covering this work will be presented, entitled *Shielding Cables in Dielectric Loss Measurements,* by E. H. Salter and *Some Problems in Dielectric Loss Measurements* by Professor C. L. Dawes.

A new test cell has been developed for determining the insulation resistance, power factor, and dielectric constant on liquid insulating materials. This cell makes it possible to test more rapidly and under better controlled conditions than was previously possible.

Some recent modifications of the Schering bridge have been made which may be of interest. The Schering bridge as ordinarily constructed necessitates the computation of capacitance and power factor of the test condenser from the values of the condensers and resistors in the other arms of the bridge. In order to eliminate the need of these computations, a modified circuit has been developed and used in the construction of several bridges whereby it is possible to adjust the bridge for the capacitance of the standard air condenser, and to make the bridge direct reading in both power factor and capacitance of the unknown condenser. These bridges have also been provided with shields on the various sections to reduce the effect of stray capacitances. In order to readily adjust the potentials of these shields, one public utility company laboratory has had a dummy bridge constructed wherein it is only necessary to set the arms of this bridge to correspond to those of the main Schering bridge in order to establish the proper potentials on the various guard circuits.

The construction of large power-factor correction capacitors has brought about the need for a ready means of measuring the capacitance and power factor of capacitors on voltages ranging from 200 to 4000 volts and with line currents as high as 75 amperes. Several stationary test sets have been constructed for this purpose, which enable power factor and capacitance to be read directly from the scale of a variable self and mutual inductor, utilizing a reflecting dynamometer as a null deflection instrument. Such testing sets are readily adjustable as to both voltage and current. The impedance of the measuring circuit, which must be inserted in series with the condenser, is so low that the drop across it does not exceed 300 millivolts.

Measurement of Non-Electrical Quantities by Electrical Means

A symposium on this subject was held during the Winter Convention, sponsored by the subcommittee on this subject, under the chairmanship of Mr. Perry A. Borden. The following papers were presented:

Magnetic Analysis of Materials, by R. L. Sanford.

Measurements of Flow by Use of Electrical Instruments, by W. H. Pratt.

Use of the Oscillograph for Measuring Non-Electrical Quantities, by D. F. Miner and W. B. Batten.

Study of Noises in Electrical Apparatus, by T. Spooner and J. P. Foltz.

Electrical Aids to Navigation,[2] by R. H. Marriott.

The increasing extent of articles in the literature describing the use and application of electrical means to the measurement of non-electrical quantities has made it practically impossible for the subcommittee to compile the many articles on the subject into a bibliography as has been done during the past three years. Hence this bibliography which has appeared annually will not appear this year except as bibliographies are available with the above papers. This growth speaks for the extension of electrical means into fields of non-electrical measurements.

High-Frequency Measurements

The subcommittee on this subject, through its chairman Professor H. M. Turner, maintains contact with the radio and high-frequency field through the Standardizaton Committee of the Institute of Radio Engineers. Under the auspices of this committee, there has recently been issued a preliminary bibliography on high-frequency measurements which is available.

The subcommittee has prepared a list of papers published during the past two years on the subject of high-frequency measurements since the symposium held in May 1927, on the subject. This list is not complete, but it reflects the progress in the art of high-frequency measurements. The list is attached to this report as Appendix A., of the complete report.

Remote Metering

Two papers were presented at the Winter Convention under the auspices of this subcommittee, under the chairmanship of Mr. E. J. Rutan. These were:

Telemetering, by C. H. Linder, H. B. Rex, C. E. Stewart, and A. S. Fitzgerald.

Totalizing of Electric System Loads,[2] by P. M. Lincoln.

The information presented in these papers supplements that reported by the subcommittee in 1928.

The subcommittee is now studying the nomenclature applicable to remote metering.

Shielding in Electrical Measurements

A symposium on Shielding in Electrical Measurements will be held at the Summer Convention 1929, under the chairmanship of Mr. H. C. Koenig. The following papers will be presented:

Shielding and Guarding Electrical Apparatus, by H. L. Curtis.

Some Problems in Dielectric Loss Measurements, by C. L. Dawes.

2. These papers will be published in the A. I. E. E. Quarterly Trans., Vol. 48, July 1929.

at the plant. A device for automatically holding the proper distribution of load between the three units in the plant has also been developed for improvement of normal operating supervision.

Propellor-Type Plants. The propeller type wheel with provision for adjustment of the blade angles to give maximum efficiency for any gate opening or maximum output for any variation of head, was introduced last year at the Chippewa Falls plant in Wisconsin where six 5000-hp. wheels operating under a head of 29.6 feet were installed. The runner blades in this case are shifted by hand after shutting down the turbine. A Kaplan turbine of 1900-hp. capacity, having an automatic arrangement for varying the pitch of the runner blades while in operation, was installed in the Devils River plant in Texas, and is the first instance of the use of this European developed turbine in America. Wheels of the greatest power of the manually-adjusted propellor type are being built for the Back River Plant of the Montreal Island Power Company in Canada, where six units rated at 8800 hp. under a head of 26 ft. will be installed.

High-Head Impulse Wheel Plants. The recently completed Bucks Creel plant on the Feather River in California develops to date the highest head at any hydro plant in America, its static head being 2562 ft. A flow of 300 cu. ft. per sec. operates the two 35,000-hp. turbines in the plant. Another outstanding installation in the Pacific Coast states was the addition to the Big Creek 2A plant of the Southern California Edison Company, of two impulse wheel units, rated at 56,000-hp. each, that exceed in capacity any impulse wheels ever built.

Trends in Steam Plant Design

Steam plant designers have been busy discussing the application of extremely high steam pressures and calling attention to the possibilities of higher steam temperatures; the selection of the most suitable method of combustion has also been a major concern. A great deal of consideration is being given to the most appropriate use of the various ideas of plant design and arrangement that have been tried out successfully in practise. The introduction of regenerative and reheating cycles, high-stream pressures, and pulverized fuel firing, has not simplified the design layout, particularly in the domain of the sub-auxiliary control equipment that is necessary. A very considerable reduction of investment charges has been made by the concentration of capacity in boilers and turbo-generators of large size. However, the relation of investment charges to the fuel and operating costs in steam plants does not appear to change to any degree for as the first is decreased by the use of large capacity units, the other has been falling because of the betterment of efficiency. In many instances the necessity of maximum capacity has been the compelling motive in the design.

High Pressures. The wider use of steam at 1200 to 1400 lb. has been conspicuous during the past year, and following the successful trial of these pressures in stations equipped with 300- to 400-lb. boilers for the major portion of their steam supply, plants are now under construction in which the entire steam output will be generated at high pressure and passed through high-pressure cross-compound turbines. The high-pressure turbines, as well as high-pressure boilers in this country, have been satisfactory adaptations of previous turbines and boiler designs. Both impulse and reaction type turbines are being used with high-pressure steam. Straight tube and bent tube boilers seem suitable for high-pressure steam generation to American designers, but in Europe, the Atmos, Benson, Schmidt-Hartmann, and Loeffler boilers, of radically new design, have been developed to overcome the suspected problems of steam generation at high pressures. Forged steel drums are employed in this country for all high-pressure boiler construction.

The necessity of reheating the exhaust steam from the high-pressure turbine, in order to avoid excessive wetness losses in the low-pressure turbine element, has led to a distribution of heating surface in the straight tube boiler setting in which the boiler surface itself is minimized, principally to provide a sufficient temperature head for the convection type superheaters and reheaters, as well as to reduce the number and cost of high-pressure boiler parts. Quite extensive air pre-heaters form a part of the high-pressure boiler setting, and in nearly all cases a high-pressure economizer is also included.

The list of high-pressure steam stations now includes plants at Boston, at Holland, South Amboy, and Deep-water in New Jersey, at Milwaukee, Kansas City, and San Francisco. Two "combustion steam generators" at the Philip-Carey Manufacturing Company, at Lockland, Ohio, will be used shortly to produce steam at 1840 lb. gage, the highest steam pressure developed to date in large boilers in this country. Both stoker and pulverized fuel firing are being used under high-pressure boilers.

Steam Temperatures. The limit of steam temperature for power generation in this country appears to be around 750 deg. fahr., although turbine guarantees can be obtained for temperatures up to 800 deg. fahr. Valves and piping can be made for higher temperatures, and alloy steels are available for superheater construction that will give a steam temperature measurably higher than present practise. The unavoidable pressure and thermal stresses, and the "creep" of metals under high temperature and stresses appear to be inhibiting any material increase in the working temperatures.

Large Boilers. Boilers are now being built to supply as much as 800,000 lb. of steam per hour, as illustrated by the new boilers for the East River Station in New York. These boilers will be of the bent-tube A-type setting, fired with pulverized coal, and will generate

steam at 425 lb. per sq. in. and 725 deg. fahr. A decidedly novel arrangement of two separate boiler sections, each composed of a standard bank of horizontal tubes and vertical headers and placed over a common pulverized coal-fired furnace, will have a maximum combined rating of the same capacity in the Hell Gate plant in New York. Boilers having normal continuous capacities of 300,000 to 450,000 lb. of steam per hour, fired either by stokers or pulverized coal, are no longer really notable. The size of riveted boiler drums was raised to a diameter of 72 in. during the past year, and are being built for pressures up to 475 lb. per sq. in. The problem of priming and of water level control at high capacity ratings seems to be leading to an increase in boiler drum volume. An interesting example of this is the cross-drum boiler installation being made in a San Francisco plant where the main drum will be 72 in. in diameter and 40 ft. along, and above which, 11 ft. higher, a supplementary dry drum 36 in. in diameter is being mounted; the two 2225-hp. boilers in the plant will be fired with fuel oil and will be subjected to widely varying steam demands, with the expectation of being able to assume a 35,000-kw. turbine load suddenly applied.

Combustion Practises. The protection of furnace walls, through cooling of their exposed surface by water or steam elements connected to the boiler circulation, has probably been of increasing application. Instances of the virtual exclusion or absence of the ordinary types of refractories from the walls of both stoker and pulverized coal fired furnaces appear to be multiplying. Metal cooling of the furnace walls seems to be practically necessary when any appreciable heat recovery is affected by air preheaters; but its chief advantage lies in the possibility of higher ratings with decreased furnace wall maintenance. Water and steam cooled walls have been developed in several types with varying amounts of metal and refractory exposure to the interior of the furnace.

Recent development of underfeed stokers has been directed towards an increase in coal burning capacity per foot of boiler width, principally through the lengthening of the coal feeding area by an extension of the retort zone. Stokers are being made up to 65 tuyeres in length. Progress has been made also in adapting the rotary ash discharge type of stoker for the efficient burning of low grade fuels in quantity. The requirements placed upon the modern stoker have brought about the wider use of steel and parts machined and cast to specifications not before justified.

Probably the most noticeable trend in pulverized coal practise has been the increased use of mills delivering their product directly to the furnace, and the horizontal arrangement of burners. The pulverized method of combustion has been applied on a large scale to almost every kind of coal commercially available in this country. The initial cost of the requisite pulverized fuel equipment external to the furnace has been reduced by placing the pulverizing mills adjacent to the furnace and by drying the coal in the mills during pulverization. Heated air from the flue gas air-preheater is ordinarily employed for mill drying although steam air-heaters are installed in some plants. The average size of boilers fired by the unit system appears to be increasing. Horizontal firing has been used with both the bin and unit mill systems, being particularly convenient with unit mill layouts. Horizontal and vertical firing are being employed together in the same furnace. Horizontal burners having relatively large coal capacity lend themselves to the use of forced draft which must be employed for the maximum of turbulence.

Turbulent firing and extensive metal cooling of the furnace walls appear to be effecting an increase in the maximum rates of heat liberation in recently constructed furnaces. Two years ago, 16,400 and 21,800 B. t. u. per cu. ft. of furnace volume per hr. represented the most frequent maximum heat liberation for bin and unit fired furnaces respectively. The newest furnaces installed in the Cahokia, St. Louis, plant develops a maximum rate of 26,700 B. t. u.; the recent Hell Gate furnaces, in New York, 35,000 B. t. u.; and the last installation at the Charles R. Huntley Station in Buffalo, a liberation of 37,900 B. t. u. per cu. ft. per hr.

The "slag bottom" furnace is one of the recent novelties in pulverized fuel practise, consisting of a furnace with a flat uncooled bottom on which the ash collects in a molten state. The liquid slag is tapped out at intervals into a stream of high-velocity water that shatters and disintegrates it into small particles that can be handled hydraulically.

Turbo-Generator Installations

Previous records for size of single-element turbines were exceeded in the 75,000-kw. capacity units installed in the plants at St. Louis and Buffalo. The Cahokia, St. Louis, unit is an 1800-rev. per min., 60-cycle machine, operating on steam at 315 lb. and 725 deg. fahr., while the Buffalo unit is a 1500-rev. per min., 25-cycle, 275-lb., 689-deg. fahr., machine. Steam is expanded in these turbines from the throttle pressure direct to the exhaust vacuum.

The 160,000-kw. tandem-compound machine that is being installed in the East River station in New York will embrace both the largest tandem-compound turbine and the largest single generator ever built. The turbine will be supplied with steam at 400 lb. and 750 deg. fahr. The generator is a three-phase, 25-cycle, 11,400-volt machine operating at 1500 rev. per minute. This generator will have two stator windings, the circuits of which are entirely separate and coupled only by the mutual reactance between them. The windings will be connected to separate bus sections whose only tie normally will be through the transformer action of the two generator windings. Smaller circuit breakers may be used with this arrangement, and it is predicted

that the effect of short-circuits on either bus will be minimized by the absolute synchronism between the two busses.

Two record breaking two-element, cross-compound turbo-generators, of 160,000-kw. capacity each, have been recently installed in the Hell Gate plant in New York City. Each unit consists of a single flow high-pressure element and a double flow low-pressure element. The throttle steam conditions are 265 lb. and 611 deg. fahr. The 137,500-sq. ft. two-pass horizontal surface condensers serving these turbines each consist of two separate condenser shells and tube nests, with a common central water box horizontally divided for inlet and outlet condensing water placed between the two halves. One-half of the double condenser is solidly attached to one exhaust nozzle of the low-pressure turbine, while the other half is flexibly connected to the corresponding nozzle.

The 208,000-kw. three-element cross-compound machines for the State Line Plant near Chicago, announced some two years ago, still remain the largest units in total capacity developed to date.

Generator Voltages and Speeds

There was an advance in voltage of large generators when the 94,000-kw., 1500-rev. per min., 16,500-volt unit went into service in the Long Beach Plant No. 3 of the Southern California Edison Company. This voltage is now exceeded in the 55,000-kw. turbo-generator in the Pekin, Illinois, plant of the Super-Power Company, that operates at 22,000 volts and 1800 rev. per min. In England, a 25,000-kw. 80 per cent power factor, 3000-rev. per min. machine, that generates at at 33,000 volts, has been recently put into service in the new Brimsdown plant, and is believed also to represent the highest capacity developed to date above 1800 rev. per min. In this country the 12,500-kw. 80 per cent power factor generators, driven at 3600 rev. per min. by the 1200-lb turbines, mark the peak capacity produced to date in machines operating at speeds above 1800 rev. per min.

Survey of Excitation Practise in Electric Power Plants

A survey has been made of the excitation layouts in some 26 modern large central stations, the majority of which have been in operation less than five years. The generating units in these stations range in individual capacity from 12,500 kw. to the largest yet operated. The frequency of application of the salient features of excitation layouts is shown by the following tabulation, which, though not including all modern stations, yet is believed to be representative of present day practise.

Design feature	Relative application
Excitation voltage of 230–250	100 per cent
Systems individual to a generator	93 per cent
Individual systems with transfer bus to spare excitation capacity (non-automatic change-over)	81 per cent
Individual systems having battery spare.	27 per cent
Individual systems using motor-gen. exciters driven from shaft generators	11 per cent
Individual systems using subexcitation of exciters	33 per cent
Installations using shunt windings on main exciters	87 per cent
Installations omitting main field rheostats	50 per cent

Survey of Auxiliary Drive Practise in Electric Power Plants

Present practise with regard to auxiliary drives has been summarized below from the data obtained from a list of some 21 modern central stations, in which the generators range in individual capacity from 12,500 kw. to the largest yet operated. Motor drive for auxiliaries is used in practically all cases, however, the installation of a steam driven boiler feed pump for starting and reserve purposes appears to be universal In approximately one-half of the stations each turbo-generator and its corresponding essential auxiliaries form a station operating unit. The sources of auxiliary power are shown by the following tabulation:

Source of auxiliary power	Relative use
Transformers ahead of generator switch	22 per cent
Generators on main unit shaft	22 per cent
Installations of house turbines	39 per cent
Transformers on busses or supply from other stations (duplicate sources in above cases)	universal

Survey of Hazards to Service Reliability in Modern Generating Stations

Special hazards of major importance prominent recently in hydroelectric plants include the failure of high head penstocks in plants that were designed and constructed some years ago. Over-voltage upon sudden loss of load at hydroelectric stations supplying transmission lines seems to be of increasing aggravation with the transmission of large blocks of power at high voltages. In steam plants, turbine blade failures and generator winding burn-outs still continue to be reported, notwithstanding the intensive research and improvement that has been accomplished in the selection and fabrication of materials.

Fires resulting from the failure of oil-filled equipment such as circuit breakers, regulators, and transformers, are probably the most common and serious hazard. Extensive damage is reported in switch houses due to the spreading of vapors arising from short circuits and faults to ground. The possibility of a bus short circuit and the resulting effects on system stability appear to be of vital concern in the design layout of the generator and transformer facilities in modern stations of large capacity.

Abridgment of

Automatic Reclosing of High-Voltage Circuits

BY E. W. ROBINSON[1]
Non-member

and

S. J. SPURGEON[1]
Non-member

Synopsis.—The experience of the Alabama Power Company with the reclosing of high-voltage circuits covering numerous installations on 22-, 44-, and 110-kv. circuits is described. No definite reclosing cycles are recommended but instead, this paper deals with various typical applications of high-voltage reclosing oil circuit breakers on the Alabama Power Company system.

Introduction

Alabama Power Company operates over a wide expanse of territory where the load density is generally low. About 1922 a large expansion program started which immediately developed the desirability of more primary substations, where the 110-kv. system might be tapped and voltage reduced to 44 kv., and of more switching stations where the existing 44-kv. lines might be interconnected. The cost of attendance at these primary substations and switching stations intervened, however, as a serious obstacle and brought about an active interest in automatic reclosing switching equipment which might allow the substitution of a daily or weekly inspection of such stations for continuous attendance.

General Discussion

No suitable reclosing relays or devices were commercially available at the time so, the Power Company started a series of experiments and developments which resulted in 1922 in the application of a reclosing device to a standard 50-kv. oil circuit breaker controlling a 44-kv. feeder. This device is of interest as being a self-contained mechanism including a motor-driven breaker operating device, reclosing relay, and lock-out relay. It required a minimum amount of power, could be operated from any available a-c. or d-c. source, and was applicable to any standard breaker by minor alterations. As originally built, the interval between breaker operations was approximately one minute, and the device could be set to lock-out after one, two, or three reclosures. Considerable numbers of each of several types of reclosing installations have been put in service and it is interesting to note than in 1928 all types showed better than 85 per cent of correct operations, and the two preferred types in excess of 95 per cent.

On the Alabama system there was originally a uniform period of one minute between breaker operations. Experience showed that this was satisfactory and subsequently the initial interval was reduced to 45 sec. and in some cases to 30 sec. Later intervals were also reduced in some instances to 45 sec. Originally, two reclosures before lock-out were provided for, and this schedule has been followed consistently. Two reclosures gave ample time for the controlled line to be restored to service, if this were possible, and there seemed to be no valid argument for a greater number, as it was extremely unlikely that a line would prove to be bad on two trials and good on the third, while on the other hand, a larger number of reclosures prolonged system disturbances vastly increased the duty on the breakers and resulted in increased cost of maintenance and inspection.

The engineers of Alabama Power Company have not been impressed with the necessity nor desirability of a standard reclosing cycle for high-voltage breakers. Instead, they have preferred to treat each case separately, taking into account the character of the controlled line, peculiarities of the load supplied, possible short-circuit duty on breaker, rupturing capacity of breaker for various duty cycles, and class of service to be maintained. In most instances the reclosing cycle is adjustable and in fact is changed from time to time depending on operating conditions. With proper consideration given these factors, satisfactory applications will result. This is borne out by the experience of Alabama Power Company where, in a six-year period, there have not been in excess of two failures of reclosing high-voltage breakers which might possibly have been avoided had the substations where these failures occurred been attended and breakers non-reclosing.

A better conception of the application of reclosing high-voltage breakers on the Alabama Power Company system may be obtained from brief descriptions of various typical installations. Therefore, descriptions and illustrations are included for one or more examples of each of the following typical applications of automatic reclosing high-voltage oil circuit breakers.

a. To plain radial feeders—44 and 110 kv.
b. To 44-kv. networks fed from one source.
c. To 44-kv. networks fed from several sources.
d. In conjunction with specially designed accessory switching equipment.

These examples follow.

Radial Feeders—44-Kv. and 110-Kv.

The application of automatic reclosing switches to radial feeders is the simplest and most common of all the applications. This type of installation is applied on a large number of substations on the Power Company's system, but because of the simplicity of the application, will not be described here. No unusual main-

1. Both of Alabama Power Co.

Presented at the Regional Meeting of the Southwest District of the A. I. E. E., Dallas, Texas, May 7-9, 1929. Complete copies upon request.

tenance problems have been encountered on radial feeder reclosing breakers.

44-Kv. Network Fed from One Source

The application of reclosing breakers to networks fed from one source presents a more difficult problem, especially when various switching stations are remotely located with respect to the source of power and attended stations. The application becomes even more difficult when it is desired to isolate automatically trouble in relatively small sections of the entire network. A good illustration of this type of network is the Blocton Loop shown in Fig. 1. This network feeds a great many important customers distributed over a large area. The network is tied together with reclosing oil circuit breakers and numerous automatic sectionalizing switches specially designed for the purpose. These circuit breakers and automatic sectionalizing switches are so arranged and timed that trouble in sections *A*, *B*, *C*, *D*, *E*, *F*, *G*, or *H* is isolated automatically from all the other sections

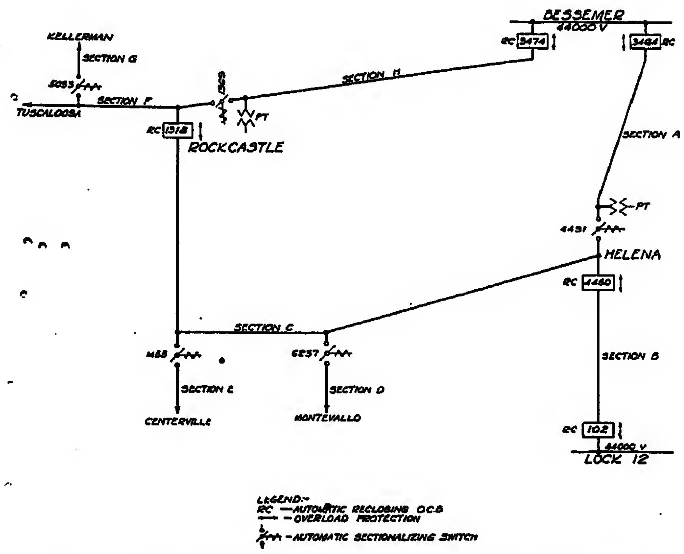

Fig. 1—Blocton Loop Automatic Switching Scheme

of line and service restored to all the network except the section in trouble. The particular type of automatic sectionalizing switch used in the Blocton Loop network is designed to reduce the number of automatic reclosing oil circuit breakers necessary to secure complete sectionalization, thereby decreasing the initial installation cost. These switches are essentially spring-actuated automatic gang-operated air-break switches. Each phase includes a high-voltage solenoid connected through an insulating member to an inverse time-limit circuit-closing relay. These switches operate in conjunction with special timing relays. Their function is to open a line automatically after it has carried excess current momentarily a given number of times within a given period of time. They are so designed that they cannot open ordinarily when the line is energized, though in some cases it is necessary to add low-voltage relays to make this positive.

The following examples describe the functioning of the Blocton Loop in case of permanent trouble. Transient disturbances are not considered as they result in no permanent derangement of the loop.

Assuming trouble in Section *A*, (Fig. 1,) automatic reclosing oil circuit breakers 3464, 1318, and 4450 open. This "notches up" the timing relays and starts a timing cycle on the automatic sectionalizing switches 1369 and 4491. In one minute, all three of the above mentioned oil circuit breakers reclose and open again immediately and the timing relays on switches 1369 and 4491 "notch up" again and start a new timing cycle. After another minute has elapsed, oil circuit breakers 3464, 1318 and, 4450 again reclose and again open immediately. The timing relays on switches 1369 and 4491 then "notch up" the third time, close their trip contacts and start a new timing cycle. When the trip contacts on the timing relay on switch 4491 are closed, the trip circuit is completed through an undervoltage relay connected to a 44,000/110-volt potential transformer, and the switch opens. Breakers 3464, 1318 and 4450, which are set for three reclosures (four openings) before lock-out, then reclose. Breaker 3464 opens immediately after reclosing the third time, and locks out, isolating Section *A*. Service is then restored to all other sections through oil circuit breakers 1318 and 4450. Switch 1369 does not open since oil circuit breaker 3474 does not open during the sectionalization and consequently there is always potential on the line between breaker 3474 and switch 1369, thus keeping the trip circuit of 1369 open at the contacts of an undervoltage relay.

All the automatic sectionalizing switches in the Blocton Loop have in their operation a certain definite relation to the terminal oil circuit breakers, and since each of them operate similarly to sectionalizing switch 4491 treated above, no further description of their detailed operation is made. The total loop is divided into relatively small sections and when a section of line is in trouble it is readily sectionalized and located.

While this loop is fed from Bessemer and Lock 12, it is considered to have one source of power supply as there is little chance of the two stations being out of synchronism and no provision is made for automatically checking synchronism either at Bessemer or Lock 12.

44-Kv. Network Fed from Several Sources

The application of reclosing breakers to networks fed from several sources is complicated by the necessity for automatic synchronizing or synchronism checking. Two good illustrations of this type of network are shown in Figs. 2 and 4.

The Alabama-Mississippi network shown in Fig. 2 has three sources of power,—Gorgas, Haleyville, and West Point. The power that can be furnished the network from West Point is not sufficient to carry much load in Alabama and the normal power flow is from Alabama to Mississippi. The chief sources of power are from Haleyville and Gorgas.

This network has three special features, all of which

are necessary for a complete automatic switching scheme of this kind. These special features consist of an automatic synchronizing device for the control of breaker 1932 at West Point, synchronism check devises at Brilliant on breaker 7858 and at Haleyville on breaker 5122, and a special timing relay at Haleyville on switch 5122. The automatic synchronizing device at the West Point Substation will close breaker 1932 only when there is potential on both the bus and line terminals and then only when both systems are in synchronism.

The synchronism check schemes at Brilliant and

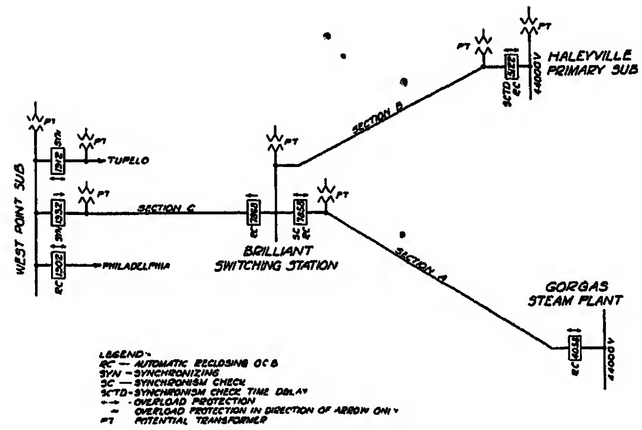

FIG. 2—ALABAMA-MISSISSIPPI AUTOMATIC SWITCHING SCHEME

Haleyville on breakers 7858 and 5122 consist of a number of relays which allow the breakers controlled to close only when the two sources of power are in synchronism, for a period of several seconds. There are other relays used in connection with the synchronism check schemes which automatically select the breaker across which synchronism is to be checked. For example, if for any reason breakers 4058 at Gorgas and 7858 at Brilliant open, breaker 7858 does not reclose until after breaker 4058 at Gorgas recloses. This scheme then allows synchronism to be checked across breaker 7858 at Brilliant. If, however, Section B is deenergized by the opening of breakers 7858, 5122, and 1932, breaker 7858 becomes automatic reclosing and synchronism is then checked across breaker 5122 at Haleyville. The synchronism check scheme on breaker 5122 is further controlled by a timing relay which is the third special feature mentioned above. The function of the timing relay is to prevent breaker 5122 from reclosing until breaker 7858 has restored power to the Brilliant side of breaker 5122, or until breaker 7858 has locked out because of trouble. This timing relay is set to operate for four minutes before closing its contacts. The closing of the timing relay contacts makes breaker 5122 full automatic reclosing. If, however, permanent potential is established on the Brilliant side of breaker 5122 before the four-minute timing cycle of the timing relay is completed, the timing cycle is terminated immediately and the synchronism check scheme functions to close breaker 5122 if the two sources of power are in synchronism. Momentary restorations of voltage across breaker 5122, due to operations of breaker 7858 during trouble, do not affect the timing cycle of the timing relay nor the functioning of the synchronism check scheme on breaker 5122. All breakers in this network are normally closed.

Assuming a permanent case of trouble occurs in Section A automatic reclosing oil circuit breakers 4058 and 7850 opens and clear the trouble. After one minute, breaker 4058 recloses, but opens automatically again immediately. It then recloses again after one minute, opens, and locks out. This isolates Section A, as breaker 7858 does not reclose, being prevented from so doing by the synchronism check scheme, on account of lack of permanent voltage on the Gorgas side. Had voltage been restored, breaker 7858 would have reclosed.

Assuming temporary trouble occurs in Section B, breakers 1932, 7858, and 5122 open. Breaker 7858 closes in one minute and restores service to Sections C and B. Breaker 1932 then synchronizes and closes immediately. The timing cycle on breaker 5122 is terminated as soon as permanent voltage is established from Brilliant. The synchronism check scheme then

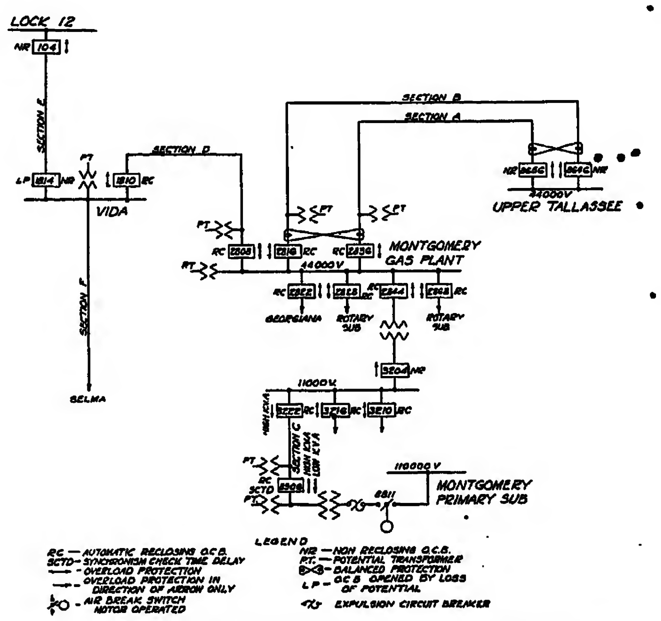

FIG. 4—MONTGOMERY AUTOMATIC SWITCHING SCHEME

checks synchronism and closes breaker 5122, thus restoring the network to normal. In case of permanent trouble in Section B, breakers 1932, 7858, and 5122 open. Breaker 7858 recloses and opens twice and locks out on the third opening. The timing relay on breaker 5122 completes its four minute timing cycle and at the end of that time breaker 5122 becomes straight reclosing and locks out after the second reclosure. Since breaker 1932 does not synchronize on a deenergized line, the trouble is isolated.

Assuming trouble in Section C, breakers 7868 and 1932 open. If the fault is temporary, breaker 7868 recloses and breaker 1932 synchronizes and closes.

If a permanent fault, breaker 7868 locks out after the second reclosure (third opening) and breaker 1932 does not close until potential is again reestablished from Brilliant.

The Montgomery automatic switching scheme shown in Fig. 4 employs the synchronism check scheme and a timing relay similar to that installed at Haleyville on breaker 5122, but is much more complex. Almost the entire Montgomery load is carried through the gas plant substation.

Montgomery is normally served from Upper Tallassee and the Montgomery Primary Substation. All breakers in the network are normally closed except breaker 2808 at Montgomery which is not closed except in emergencies.

Breakers 8656 and 8646 at Upper Tallassee open for trouble on lines designated as Sections *A* and *B*. Breakers 2836 and 2816 are automatic reclosing and lock out after the second reclosure (third opening).

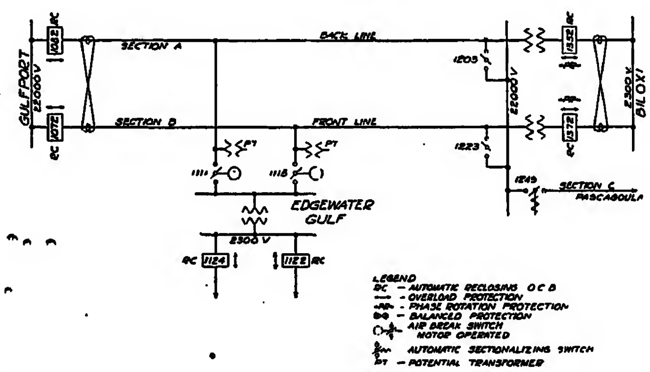

FIG. 6—GULFPORT-BILOXI AUTOMATIC SWITCHING SCHEME

If for any reason potential fails on both the lines from Upper Tallassee, breaker 3204, which is non-reclosing, opens on reverse power. The primary substation will then carry the 11-kv. load in Montgomery. When breaker 3204 opens, the 44-kv. bus is deenergized and breaker 2808 closes after a few cycles and breakers 2836 and 2816 both open, if not already in the open position. These provisions are made for isolating the power supply from the primary substation, since the entire load of Montgomery cannot be carried from that source and the source of power from Lock 12 through Vida is not adequate to carry the Montgomery load and the load on all the 44-kv. feeders. When potential is again restored to the Upper Tallassee side of breakers 2836 and 2816, they again reclose. All switching at Montgomery is brought to the attention of the local organization through a signal system, and after the automatic switching as described above is performed, an operator goes to the station, closes breaker 3204 and opens breaker 2808, thus restoring the station to normal.

Any trouble in the transformer bank at the Gas Plant Substation is cleared by breaker 2844, which locks out after the second reclosure (third opening) and breaker 3204, which is non-reclosing.

A fault in Section *C* is isolated by automatically reclosing breakers 3222 and 8906. Breaker 8906 is equipped with a synchronism check scheme and a timing relay as explained in the above discussion. Ordinarily, if not interfered with by the synchronism check scheme or timing relay, breaker 3222 closes in one minute. If the fault is temporary, the four-minute timing cycle of the timing relay on breaker 8906 is terminated as soon as permanent voltage is established from the gas plant substation. The synchronism check scheme then checks synchronism and breaker 8906 closes, thus restoring the network to normal. If the fault is permanent, breaker 3222 locks out after the second reclosure (third opening). The timing relay on breaker 8906 then completes its four-minute timing cycle, and at the end of that time, the breaker becomes straight automatic reclosing and locks out after the second reclosure (third opening). It is noted that breaker 3222 opens on overload toward the primary substation. This breaker is set to open at a higher kv-a. and longer time than breaker 8906 for a power flow toward the 110-kv. bus. This allows breaker 8906 to open in advance of breaker 3222 in case the 110-kv. line is deenergized or when trouble occurs in the primary substation. Under these conditions, breaker 8906 does not reclose until power is again applied to the 110-kv. line, and then only after synchronism is checked. Breaker 8906 is opened also by overload relays set for relatively high kv-a., and operates only when there is trouble in Section *C*.

When trouble occurs in Section *D*, breaker 1810 opens on overload. Breaker 2808 immediately closes on failure of potential on Section *D*. If trouble is only temporary, power is restored by breaker 2808, and in one minute, breaker 1810 recloses. An operator then goes to the Montgomery gas plant substation and opens breaker 2808 to restore the system to normal. If, however, trouble persists after the first and second reclosure, then both breakers lock out after their second reclosure (third opening) and the trouble is isolated in Section *D*.

When trouble occurs in Section *E*, breaker 104 opens and clears the trouble. This opens breaker 1814 on failure of voltage. Breaker 2808 then closes and restores service to Sections *D* and *F*.

When trouble occurs in Section F, the same operations take place as when trouble occurs in Section *E*, but the operator at Lock 12 is able to restore service to Section *E* when breaker 1814 opens upon failure of bus voltage. When breaker 2808 closes, it provides a new source, so that breaker 1810 may open three times and lock out, leaving Section *D* supplied through breaker 2808.

None of these extensive applications of reclosing

breakers has developed any particular or fundamental difficulties in reclosing high-voltage circuits.

In Conjunction With Specially Designed Accessory Switching Equipment

The use of automatic reclosing high-voltage oil circuit breakers in conjunction with specially designed accessory equipment is common on the Alabama Power Company and affiliated systems. Fig. 6 covers an interesting application at Gulfport, Mississippi.

The automatic switching scheme described includes three distribution substations,—Gulfport, Edgewater Gulf Hotel, and Biloxi,—with two lines connecting Gulfport and Biloxi as shown in Fig. 6. The source of power is Gulfport and the network is designed to eliminate interruptions to Edgewater Gulf Hotel and Biloxi so far as possible. The loop is normally closed at Biloxi through the two transformer banks and their low-voltage automatic reclosing breakers 1372 and 1352. A transfer bus at Biloxi allows Pascagoula to be served from either the "back" or "front" line through the gang-operated air-break switches 1203 or 1223. Normally, switch 1223 is open and switch 1203 is closed. The line to Pascagoula is equipped with automatic sectionalizing switch 1249, which isolates trouble on that line after the "back" line terminal breakers 1352 and 1082 have opened twice within a one and one-half minute period.

Assuming a permanent case of trouble on the "front" line, both the automatic reclosing oil circuit breakers 1072 and 1372 act as straight automatic reclosing breakers which lock out after the second reclosure. When a permanent fault occurs on the line to Pascagoula, the same automatic switching takes place as when trouble occurs on the "back" line except that the automatic sectionalizing switch 1249 isolates the trouble after the second opening of breakers 1082 and 1352 and service is restored to the "back" line by the reclosing breakers 1352 and 1082 after which the Edgewater Gulf Hotel is transferred to the "back" line as previously explained.

Conclusions

There is nothing experimental about automatic reclosing of high-voltage circuits. Selection of breakers and choice of reclosing duty cycles should be made separately for each application, based on the various factors outlined. Highly reliable reclosing relays or reclosing devices are now available from various manufacturers. While with automatic reclosing of circuits attendants at stations and substations become unecessary, extremely careful and regular inspection and maintenance of breakers and reclosing equipment is essential; in fact vastly more important than in the case of attended stations or substations. Even at points where attendants are stationed, it is sometimes economical and desirable to install reclosing equipment, either to improve service or to reduce attendance.

CORRESPONDENCE

To the Editor of the Journal:

In the paper on *Electrification of Oil Pipe Lines in the Southwest*, by D. H. Levy, published in the Journal of the A. I. E. E., June 1929, p. 434, it is stated that squirrel-cage induction motors are used for driving the centrifugal pumps in all cases, and that if there were a power-factor penalty the use of static condensers would be justified in most cases.

The paper describes the electrification of six pipe lines, each several hundred miles long, and with about 300-kw. average load for each of the stations tabulated. Evidently, many of the motors are over 50-hp. Synchronous motors of such sizes are suitable for driving centrifugal pumps in many cases. Since static condensers cost from $15 to $25 per kv-a., and since synchronous motors of the sizes considered cost only about $1 to $8 per kv-a. more than induction motors, it would appear that if there is a power-factor penalty, synchronous motors should be seriously considered instead of static condensers, for new installations.

A useful basis of comparison, where the synchronous motor is to operate in parallel with other induction motors, is to take on the one hand an 80 per cent power-factor synchronous motor, and on the other hand an induction motor with a static condenser of the same kv-a. rating as the synchronous motor. These give practically the same improvement in system power factor. This is shown as follows: An induction motor of 100 kw. has about 50 kv-a. magnetizing reactive kv-a. (lagging). An 80 per cent power-factor synchronous motor of 100 kw. has a rating of 125 kv-a., and takes 75 reactive kv-a. leading. The difference between the synchronous motor and the induction motor is, therefore, equivalent to 125 reactive kv-a., leading, and this is equal to the rating of the synchronous motor.

It is to be noted that the synchronous motor is chiefly advantageous where the remainder of the load has a lagging power factor, or where the power-factor penalty is so described that it pays to operate with the power factor leading to some extent.

To supply a large number of motor-driven pump stations, scattered 30 or 40 miles apart, as described for the pipe lines, is to a considerable extent a transmission problem, and the transmission costs are less for a high lagging power factor or a leading power factor. If one company owned both the power lines and the pipe lines, so that the type of motor depended on the over-all economy rather than on the enforcement or the particular terms of a power-factor penalty clause, then synchronous motors would seem to be the logical choice for this application.

H. B. Dwight

Boston, Mass.

INSTITUTE AND RELATED ACTIVIT

The Pacific Coast Convention

SEPTEMBER 3-6

A technical program of diversified values and the enjoyable recreation to be found at one of California's most famed seashore resorts, are offered to those who attend the 1929 Pacific Coast Convention at the Hotel Miramar, Santa Monica, Calif., September 3 to 6.

Nineteen papers are included in the general technical program, in addition to twelve Student technical papers. Sports, trips, and other entertainment are important features of the Convention, a complete program of which was published in the August issue of the JOURNAL, page 642.

District Meeting in Chicago December 2-4

A three-day District Meeting will be held by the Great Lakes District of the Institute in Chicago, December 2 to 4.

Nineteen technical papers have been proposed dealing with the general subjects of power stations, transmission and distribution, communication, and general research and development.

A Student Session will be one of the important features of the meeting.

Further details of the convention will be announced in the next issue of the JOURNAL.

World Engineering Congress Delegates to Visit Washington

On their way to attend the World Engineering Congress at Tokio, Japan, the major delegation of foreign and national engineers will arrive in Washington, Wednesday, October 2. O. C. Merrill, Chairman of the Entertainment Committee, has requested L. W. Wallace, Executive Secretary, American Engineering Council, to form a reception committee composed of the presidents of the engineering organizations in Washington.

Those who have already consented to serve on this committee are: Starr Truscott, President of the Washington Society of Engineers; W. E. Doying, Chairman of the Institute's Washington Section; Admiral H. I. Cone, representing the American Society of Mechanical Engineers; E. W. James of the American Society of Civil Engineers; G. K. Burgess, of the American Institute of Mining and Metallurgical Engineers; and Charles H. Tompkins, Chairman of the Washington Post of the American Society of Military Engineers. The Japanese Ambassador is entertaining the guests of honor at dinner on the evening of their anticipated arrival, October 2.

American Electric Railway Association Convention

SEPTEMBER 28-OCTOBER 4

At the coming convention of the American Electric Railway Association, at Atlantic City, September 28-October 4, inclusive, the subject of "Today's Transit Task" will be discussed by three of industry's leaders, from the standpoint of general utility, improvement of cars and buses, and "ways of modernizing the human organization of local transportation companies." Other subjects to be taken up will be traffic regulations, education and training, small city problems, and interurban and long-distance operation of buses. The broad subject of "Progress" will include valuable discussions on the benefits of unified transportation maintenance of motor buses, etc.

Entertainment plans also are well formulated, with bridge, golf, and other attractions scheduled.

Reduced fares are being offered by all railroads and special folders of information in this regard are being sent to all members.

Illuminating Engineers to Me Philadelphia

The program for the forthcoming twenty-third vention of the Illuminating Engineering Society, the Bellevue-Stratford, Philadelphia, September 2 some 25 papers by leading illuminating engineers c vital interest to all branches of the lighting art. Ar to the regular convention program, elaborate prep been made for a pre-convention meeting September interested in lighting service, while another meetin mittee on Lighting Service will be held the morning o September 25th. One entire session will be devot Golden Jubilee, commemorating the 50th annive tion of the invention of the incandescent lamp b Edison. G. Bertram Regar, of the Philadelphia I pany, is Chairman of the Convention Executive Co

Industry to Cooperate wi Electrochemists

In conjunction with the fall meeting of the Ame chemical Society, to be held at Pittsburgh, Pa., Sep special trips will be arranged to the works of the Electric & Mfg. Company, Firth Sterling Ste National Tube Company, U. S. Aluminum Compa Light Company, Carnegie Steel Company, Pit Company, U. S. Light Storage Battery Compa Laughlin Steel Corporation, Lustro Coated Ste Standard Steel Spring Company, National Caske

The meeting will have a number of technical special sessions devoted to a symposium on " of Electrochemists to Aeronautics," "Electroth "Electrodeposition." Sight-seeing tours, golf, a program for the ladies have been carefully plann

There will also be an exhibit of recently develo and electrochemical products.

STANDARDS

Three New American Standards

Advice has just been received of the approval by Standards Association of three new standard *Dimensions Governing Fit of Four-Pin Vacuum T Arrangement of Terminals*, the work of a Section on Radio under joint sponsorship of the A. I. Institute of Radio Engineers. This was approved a Tentative Standard July 26, 1929. The other two *Graphical Symbols for Telephone and Telegraph Us for Hydraulics*. Both of these projects are the resul of the Sectional Committee on Scientific and Eng bols and Abbreviations of which the Institute is o sponsors. Both were approved as American Tenta as of July 26, 1929.

Standards for Relays

A subcommittee of the A. I. E. E. Standards C just been organized to develop A. I. E. E. Standa This committee which will be known as Worki No. 48 and will be under the chairmanship of Geor Asst. General Superintendent of the New Yor Electric Light and Power Company will cover rel ing devices for the protection and control of app cuits for the generation, transmission conversio and utilization of electric power. The standards

relays as applied to telephone, telegraph, traffic control and similar devices. Work will begin actively early in the fall.

American Standards for Electric Welding to be Developed

A Sectional Committee on Electric Welding is now being organized under the rules of procedure of the American Standards Association. This committee will have as the basis of its work the two A. I. E. E. Standards, Nos. 38 and 39, Electric Arc Welding Apparatus and Resistance Welding Apparatus. The joint sponsors for the project are the A. I. E. E. and the National Electrical Manufacturers Association.

American Standards for Oil Circuit Breakers and for Disconnecting and Horn-Gap Switches to be Developed

The joint sponsors, the A. I. E. E. and the National Electrical Manufacturers Association, are organizing a Sectional Committee under the rules of procedure of the American Standards Association to develop American Standards for Oil Circuit Breakers and for Disconnecting and Horn Gap Switches. Because of the similarity of the two projects it is felt that the work can be most efficiently handled by a single sectional committee, divided into necessary subcommittees. The basis for the committee's work will be the two A. I. E. E. Standards, Nos. 19 and 22.

NATIONAL RESEARCH COUNCIL

ADVISORY AID SOLICITED FROM ENGINEERS AND SCIENTISTS

In a desire to interpret science graphically to the world at large with regard to the progress it has made during the last century, trustees of the Chicago World's Fair Centennial Celebration planned for 1933 are enlisting the aid of engineers and scientists from all parts of the United States. The Research Council Science Advisory Committee has been appointed to cooperate in formulating a basic plan to adequately portray these advances to the public, all fields of science and engineering being represented in the personnel of the committee appointed as follows: Doctor F. B. Jewett, Chairman, Doctor M. I. Pupin, Mr. R. F. Schuchard, W. D. Ryan; Maurice Holland, Executive Secretary. These appointments were made by Doctor George K. Burgess, Chairman of the Council.

The committee will meet early in the fall to submit ideas to be coordinated into one central plan for the Exposition, of which science will be a dominating feature. A preliminary meeting has already been held to begin the work and outline the project. Members of the Executive Committee of the Advisory Board are: Doctor F. B. Jewett, Chairman; Doctor George K. Burgess; Gano Dunn; Doctor Vernon Kellogg; Doctor M. I. Pupin, and Doctor William Allen Pusey.

AMERICAN ENGINEERING COUNCIL

COMMITTEE APPOINTED ON ENGINEERING AND ALLIED TECHNICAL PROFESSIONS

With an aim to improving the status of the profession and uncovering new possibilities for the betterment of society, the appointment of a special committee to be known as the Committee on Engineering and Allied Technical Professions, to direct such a study under the auspices of the American Engineering Council has been announced by President Berresford.

This Committee will consist of H. C. Morris, retired mining engineer of Washington, D. C., Chairman; A. B. McDaniels of Washington, D. C., representing the American Society of Civil Engineers; Conrad N. Lauer, of Philadelphia, representing The American Society of Mechanical Engineers; and H. A. Kidder, representing the American Institute of Electrical Engineers; and L. W. Wallace, of Washington, Executive Secretary of the Council. Individual committees of the A. S. M. E., the A. I. E. E., and the Washington, D. C. Society of Engineers will work with this joint committee, to "collect, tabulate, analyze, and disseminate information—and to give a clear conception along the various lines of endeavor."

As a result of the survey the Council hopes to be in position to give expert guidance in matters affecting the professions and contingent branches in both local and national relations.

A NEW EDITION OF CONSTITUTION AND BY-LAWS

Following the adoption of the revised and amended Constitution and By-Laws of American Engineering Council at the meeting of the Assembly in January, 1929, Council has edited and delivered the revised document for printing.

The committee upon the final editorial revision of the amended Constitution is composed of: Gardner S. Williams, Detroit Engineering Society; James R. Withrow, Engineers Club of Columbus; and W. C. Lindemann, Engineers Society of Milwaukee.

The booklet will be carefully indexed and will carry a list showing the geographical distribution of the member organizations of Council. Engineers interested may secure copy of the new edition by addressing the American Engineering Council, 26 Jackson Place, Washington, D. C.

A. E. C. PUBLISHES ROSTER

American Engineering Council is having printed a roster of prominent engineers who have served as members of its Assembly since the organization of Council in 1921. This roster will be a 6 x 9 in. booklet, of 48 pages and will contain brief professional biographies of the 191 engineers who have at one time or another served as members of the Assembly of American Engineering Council.

The 1929 edition of the roster will contain the biographies of many well-known men, among them W. L. Abbott, L. P. Alford, A. W. Berresford, William Boss, Mortimer E. Cooley, Alex Dow, Gano Dunn, W. F. Durand, C. E. Grunsky, G. H. Herrold, Herbert Hoover, F. L. Hutchinson, D. S. Kimball, Fred R. Low, Anson Marston, M. I. Pupin, E. W. Rice, Jr., Chas. M. Schwab, G. T. Seabury, S. W. Stratton, Francis Lee Stuart, G. S. Williams, James R. Withrow. Copies may be had by addressing 26 Jackson Place, Washington, D. C.

A. I. E. E. Directors Meeting

The first meeting of the Board of Directors of the American Institute of Electrical Engineers for the administrative year beginning August 1, was held at Institute headquarters, New York, on Tuesday, August 6, 1929.

There were present: President Harold B. Smith, Worcester, Mass.; Past-President Bancroft Gherardi, New York, N. Y.; Vice-Presidents H. A. Kidder, New York, N. Y., and E. B. Merriam, Schenectady, N. Y.; Directors H. C. Don Carlos, Toronto, Ont.; F. C. Hanker, East Pittsburgh, Pa.; E. B. Meyer, Newark, N. J.; J. Allen Johnson, Niagara Falls, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; W. S. Lee, Charlotte, N. C.; J. E. Kearns, Chicago, Ill., and C. E. Stephens, New York, N. Y.; National Secretary F. L. Hutchinson, New York.

The minutes of the Directors Meeting of June 25, 1929, were approved.

A report was presented of the meeting of the Board of Examiners held July 31, and the actions taken at that meeting were approved. Upon the recommendation of the Board of Examiners, the following action was taken upon pending applications: 22 Students were enrolled; 68 applicants were elected to the grade of Associate; five applicants were elected to the grade

of Member; one applicant was elected to the grade of Fellow; 31 applicants were transferred to the grade of Member.

As provided in Sec. 22 of the Constitution, Messrs. H. D. Reed and H. H. Wait were made "Members for Life."

The Board ratified the action of the Finance Committee in approving for payment monthly bills for July amounting to $40,256.58, and for August amounting to $23,331.83. The July disbursements included traveling expenses of officers and delegates in connection with the Summer Convention, at Swampscott, Mass., in June.

Consideration was given to recommendations that had been made at a number of District conferences on student activities held in various parts of the country, that National or District officers visit the Student Branches annually or biennially, and to the recommendation of the Committee on Student Branches and of the Student Branch Counselors in conference during the Summer Convention in June that traveling expenses be paid at the usual rate for the Vice-Presidents to visit the Student Branches, as well as the Sections (already authorized) within their Districts. The Board voted that the provision covering traveling expenses for Vice-Presidents for visits to Sections be amended to read as follows: "For each Vice-President of the Institute to one meeting each year of each Section and each Student Branch within his Geographical District, it being understood that joint meetings of Sections and Branches will be arranged as far as may be expedient."

Carrying out the previous action of the Directors at the June meeting, in approving the recommendation made at the Conference of Officers and Delegates held June 24, that "Regional Meetings be hereafter referred to as 'District Meetings' and that the By-laws be changed accordingly," Secs. 35 and 67 of the By-laws were amended by the substitution of the terms "District Meeting" for "Regional Meetings" and "District Meeting Committees" for "Regional Meeting Committees."

The President announced the appointment of committees and representatives of the Institute for the administrative year beginning August 1, 1929. (A complete list of committees and representatives appears elsewhere in this issue.)

In accordance with the By-laws of the Edison Medal Committee, the Board confirmed the appointment by the President of Mr. Samuel Insull as chairman of the Committee for the administrative year beginning August 1, and of the following members of the Committee for terms of five years each beginning August 1, 1929: Messrs. L. W. W. Morrow, W. S. Rugg, and R. F. Schuchardt; and of Professor C. F. Harding to fill the unexpired term of Charles F. Brush (deceased), ending July 31, 1933. Also, the Board elected three of its own members to serve on the Edison Medal Committee for terms of two years each beginning August 1; namely, Messrs. J. Allen Johnson, W. S. Lee, and A. M. MacCutcheon.

As required by the By-laws of the committee, the Board confirmed the appointment by the President of Messrs. A. C. Bunker, H. P. Charlesworth, and C. C. Chesney as members of the Lamme Medal Committee for the three-year term beginning August 1, 1929, and of Professor Charles F. Scott as Chairman of the committee for the coming year.

Local Honorary Secretaries were appointed for terms of two years each, beginning August 1, to succeed those whose terms expired July 31, 1929, as follows: Axel F. Enstrom, for Sweden; A. P. M. Fleming, for England; T. J. Fleming, for Argentina; P. H. Powell, for New Zealand; Guido Semenza, for Italy; F. M. Servos, for Brazil.

In connection with designation by the President (as authorized by the Directors in March) of Mr. H. A. Kidder for appointment as a member of the American Engineering Council's Committee on Engineering and Allied Technical Professions, with the understanding that he would become the chairman of an Institute committee on the same general subject if and when it seemed desirable to set up a separate Institute committee, the duties of which would include cooperation with the Council's committee, the Board adopted a resolution authorizing the President "to appoint a Committee on the Engineering Profession, consisting of five or seven members, to consider and report to the Board of Directors upon various matters affecting the status of the engineering profession; one function of the committee to be cooperation with the American Engineering Council's Committee on Engineering and Allied Technical Professions."

Inasmuch as the new Committee on the Engineering Profession will cooperate with American Engineering Council's Committee on Engineering and Allied Technical Professions, and as one of the subjects to be considered by the latter committee is that dealing with the licensing of engineers, it was voted that the Special Committee on Licensing of Engineers, which has been in existence for the past few years, be discontinued and its former functions assigned to the new Committee on Engineering Profession.

An invitation from the American Society of Mechanical Engineers to appoint two official delegates to participate in the observance of the Fiftieth Anniversary of the Society in April 1930 was accepted, and the President was authorized to appoint the delegates.

It was decided that the October meeting of the Board of Directors will be held in New York on Friday, October 18, and that the December meeting will be held in Chicago, during the Chicago District Meeting, December 2-4.

Other matters were discussed, reference to which may be found in this and future issues of the JOURNAL.

Secretaries' Fourth Conference

The Fourth Conference of Secretaries of Engineering Societies met June 6-7, in the club rooms of the Western Society of Engineers, Chicago, Ill.; E. S. Nethercut, Secretary of the Western Society of Engineers, presided. A. W. Berresford, President of American Engineering Council addressed the conference, and was followed by L. W. Wallace, Executive Secretary, who explained briefly the history of American Engineering Council's participation in the Engineering Secretaries Conferences.

C. R. Sabin reported that the Committee on Standardization of Membership Requirements and Transfer of Membership between Local Societies had prepared a questionnaire which was sent to the various engineering societies and that approximately 25 societies had shown interest toward the standardization of membership requirements recommended by the previous Secretaries Conference. The conference felt greatly the need of an up-to-date list of engineering and allied technical societies of the United States and voted to request American Engineering Council to prepare as accurate a list as possible. Such a list will soon be published in the A. E. C. Bulletin.

Following the report of the committee, the conference adopted the committee's recommended form for intersociety membership transfer.

The report of Ernest Hartford, Assistant Secretary, American Society of Mechanical Engineers, Chairman of the Committee on Physical and Financial Relations Between the Local Sections of National Societies and Local Engineering Societies, gave many helpful suggestions for methods of cooperation between national and local engineering organizations.

C. E. Billin, Chairman of the Committee on Participation in Civic Affairs, presented the results of a questionnaire showing that practically all engineering societies felt that participation in civic affairs was both helpful to the society and the membership. The conference voted to recommend that each engineering organization appoint a standing committee on public affairs.

New Volume of Research Narratives Available

A third group of fifty Research Narratives was completed in May. Requests for these Narratives in book form having continued, a third volume was printed for delivery about the middle of August. To this, General John J. Carty, Vice-President, American Telephone & Telegraph Company, Past-President, American Institute of Electrical Engineers, has written a brief Introduction, in part as follows:

"The publication of Popular Research Narratives does more than provide scientific reading in an entertaining and instructive manner. They constitute in themselves a distinct contribution to the cause of scientific research because they present to the reader in authentic form, concrete examples of the methods, vicissitudes and triumphs of scientific research. . . . The progress of scientific research in our country depends in the last analysis upon the support which it receives from the public. There is no lack of problems to be solved, all of which in one way or another affect the welfare of the Nation, and there will be no lack of competent scientific investigators who will solve them if the necessary financial support is provided. . . . .

But the higher values of scientific research must be stated in terms of human achievement, the elimination of poverty and disease, the advancement of learning, the growth of right living and good understanding among men. . . . According to the vision of Science, life must no longer be regarded as a struggle among men for a limited store where one man's gain or one nation's gain must be another's loss. Under the banner of scientific research we are asked to join with our fellow men, working together in controlling and utilizing the boundless forces of nature. Such is the message of Research Narratives."

The National Electrical Code

The 1929 edition of the National Electrical Code has been declared an Approved American Standard by the American Standards Association. For 30 years the Code, originally drafted in 1897, has been the basic guide for safe practises in the wiring of consumer premises for the use of electricity for light, heat, and power, and the forthcoming edition is the 15th revision of the original text.

The Code was drafted by a sectional committee under the sponsorship of the National Fire Protection Association, and the electrical committee includes 75 members and alternates representing 36 national and local organizations.

Supplies of the new edition may be ordered from the American Standards Association, 29 West 39th Street, New York, or from the National Board of Fire Underwriters, 85 John Street, New York.

Diesel and Oil Engine Course at Brooklyn Polytechnic Institute

Direct and personal supervision of the conduct of the evening course in Diesel and oil engines which is to be given by the Department of Mechanical Engineering, Brooklyn Polytechnic Institute, is in the hands of Professor E. F. Church, Jr., Head of the Department. Lectures will be delivered by Julius Kuttner, editor of *Oil Engine Power* and for two years test engineer and designer for oil engine manufacture in Germany. Edgar J. Kates, for the past twenty years connected with the design and construction of several types of oil engines including supervision of layout, erection, and operation of numerous oil engine installations, will discuss the design, management, and cost of Diesel power plants, while Professor W. J. Moore, in charge of the Institute's laboratory work, will personally conduct laboratory exercises and demonstrations in conjunction with the course. Students may register any time after Sept. 1.

PERSONAL MENTION

Blight S. Robinson, formerly Assistant Editor of the *Electrical World*, has been appointed to the staff of the Waterbury Cable Service, Inc., New York.

B. L. Conley has resigned as Electrical Engineer of The Holtzer-Cabot Electric Co., Boston, Mass., to accept the position of Chief Engineer with The Sunlight Electrical Mfg. Co., Warren, Ohio.

Gordon R. Anderson has been recently transferred from the Indianapolis Works of Fairbanks Morse & Co. to the Beloit Works, where he will be in charge of the Single-phase Motor Division of the Company.

George W. Bricker, Jr., who has been with H. C. Hopson & Co., Inc., New York, N. Y., has become associated with Lybrand Ross Bros. & Montgomery, Boston, Mass. to specialize in public utility problems in the capacity of accountant.

Myron Zucker has joined the Detroit Edison Co., having resigned from the General Electric where he has been working in the Central Sta. Department with Doctor E. F. W. Alexanderson on stability, high-speed excitation and thyratrons.

H. W. Young, President of the Delta-Star Electric Company, Chicago, returned on the *Olympic* August 7, from a two-months' trip to France, Germany and England. While abroad, he visited many of the European manufacturers of high-voltage switching equipment.

Paul M. Downing, Vice-President in Charge of Electrical Construction and Operation of the Pacific Gas and Electric Company has just been elected First Vice-President and General Manager, to succeed Frank A. Leach, Jr., whose retirement has just been announced.

W. M. Vernor, recently of the Westinghouse Electric International Co., has been appointed salesman for the Westinghouse Electric Elevator Company in the New York District. While with the International Co., Mr. Vernor spent three years in Manila and Hongkong.

John S. Riddile, who for nearly ten years was associated with Ralph D. Mershon in hydroelectric developments in Canada, has been made Executive Engineer of the Shawinigan Water & Power Company which last year purchased the Laurentide Power Company, Ltd., Grand Meere, with which Mr. Riddile was previously identified.

Yasudiro Sakai has recently been elected a Fellow of the Royal Society of Arts, London, England. Mr. Sakai joined the Institute in 1907 as Associate and was advanced to Member in 1919. He is a Member of the Examination Committee of the Imperial Government of Japan, as well as a patent attorney and consulting engineer at in Tokio.

Gilbert H. Dunstan recently resigned as Instructor in Drawing and Machine Design at Tulane University, La., and has accepted a position as Instructor in Civil Engineering at the University of Southern California. He will have charge of work in drawing and descriptive geometry, with students in the branches of engineering, and in addition, expects to teach one course in the Electrical Engineering Department.

Ross Ewing, on August 1, 1929, became associated with C. M. Adams as Manufacturers' Representative for the American Steam Pump Company, the Clarage Fan Company, J. Struthers Dunn, H. H. Stricht & Co., H. E. Trent Company, Edwin L. Wiegan Co. and the Vicking Products Company. Mr. Ewing was previously with Westinghouse interests in Detroit. He remains in that city in his new connection.

F. B. Philbrick, for nine years at the Gamewell Company's Factory as Engineer, has been appointed District Sales Manager for the Pacific Coast, with headquarters at 939 Larkin Street, San Francisco, California. Mr. Philbrick has had extensive experience in fire-alarm and police signal engineering and his new ap-

pointment will include making surveys and recommendations for the improvement of fire and police signaling systems in that vicinity.

O. W. A. Oetting, effective September 1st resigned from his position as Chief Engineer of the Willard Storage Battery Company of Cleveland, Ohio, which he joined in 1917 as an engineer in the Sales Department on applications of storage batteries to electrical systems of cars. Prior to his connection with the Willard Company, Mr. Oetting was in the Research Department of the Westinghouse Electric & Manufacturing Company. He has made no announcement of future plans except a trip shortly to the Coast.

T. J. Fleming, who has been Transmission Engineer for the Santa Monica Bay Telephone Company, Associated Telephone Company, Long Beach, Calif., has been made its Transmission and Protection Engineer with offices in the Petroleum Securities Building, Los Angeles, Calif. The Associated Telephone Co., which was formed by a consolidation of six independent telephone companies in and about Los Angeles, is an operating unit of the Associated Telephone Utilities Company, with several such units throughout the United States.

Charles E. Taff, until recently Assistant Manager of Construction for the Standard Underground Cable Company, at Pittsburgh, is now Manager of Henry Ihle, Incorporated, Brooklyn, of which he also has been elected a director and the secretary. Mr. Taff's connection with the Standard Company dates back to 1907 and includes the installation of cable systems throughout the United States and Canada, as well as active service in the electrification of the Pennsylvania Railroad Station Terminal in New York, work on the 33-kv. submarine cable crossing at Cohkia Plant, St. Louis, and the Holland Tunnel.

Obituary

E. H. Smith, Equipment Engineer of the Bell Telephone Laboratories, Inc., died June 11, 1929. He was born at Spencer, Massachusetts, November 13, 1888, and attended the Leicester Academy, Leicester, Massachusetts and Worcester Polytechnic Institute. In 1911 he joined the Western Electric Company's Engineering Department, and from that time until 1923 was occupied with telephone equipment and telephone system engineering,—nine years in the Chicago and New York offices of the company; for thirteen years he was at the Hawthorne plant of the company. He became an Associate of the Institute in 1923 and was advanced to the grade of Member in 1926.

Max G. Newman, Electrical Engineer for the General Electric Company at Pittsfield, Mass., and an Associate of the Institute since 1912, died July 14, 1929. Mr. Newman was assistant to the head of the Experimental Division of the company's Pittsfield works. He was born at Fryburg, Maine, April 21, 1885, and was graduated from the Fryburg Academy in 1902. He was graduated in 1907 from the University of Maine, immediately after which he joined the General Electric Company's Schenectady office, engaged on test work. In 1909 he left the test work to take a position in the standardizing laboratory at Schenectady, removing to the company's laboratories at Pittsfield in 1910. His record with the company covered a period of twenty years of representative service.

Armistead K. Baylor, 61, General Electric commercial engineer and veteran of the electrical industry, died suddenly early on the morning of August 1 at Ipswich, Mass., where he was summering. In 1891 Mr. Baylor went with the Thomson-Houston Electric Company at West Lynn, Mass., and removed to Schenectady, N. Y. in 1894 when the headquarters and main offices of the General Electric Company were established there. In 1896 he went abroad to become manager of the Traction Department of the British Thomson-Houston Company, becoming General Sales Manager there. After 14 years he returned to this country to re-enter the General Electric organization, and for several years was in the commercial general department. Mr. Baylor was also Vice-President, director and a member of the Executive Committee of the Edison Electric Appliance Company. He became a Member of the Institute in 1926.

Charles W. Kincaid, a special engineer in the Industrial Motor Engineering Department of the Westinghouse Electric & Mfg. Co., and an Associate of the Institute since 1913, died Sunday, July 14, after an extended illness. He was born in Pittsburgh in 1889 and was educated in the Pittsburgh public schools, followed by a course at the University of Pittsburgh, from which he was graduated in 1910 with the degree of E. E. He entered the employ of the Westinghouse Company that same year and during his 19 years of service with the company held successively positions of a-c. motor designer, Section Engineer on a-c. motors and Consulting Specialist on industrial problems. For several years he was closely associated with B. G. Lamme, at Mr. Lamme's death taking up and carrying on much of the experimental and theoretical investigation of induction motor problems initiated by Mr. Lamme. He was the author of numerous technical articles, published of recent years in *The Electric Journal*, on the fundamental theory of the various types of induction motors, as well as other papers presented before the Institute and included in its Transactions.

Charles B. Larzelere, Designing Engineer of the General Electric, Philadelphia, died in that city June 25, at the age of 54. Mr. Larzelere was born at Seneca Falls, New York, and was a graduate of the Mynderse Academy there; also of Cornell University, from which he was graduated in 1897 with a degree of M. E. in E. E. He began his technical work with one year in charge of a small electric lighting plant, after which, in 1899, he became draftsman for the General Electric Company at Schenectady. Three years later, he removed to England to become Designing Engineer in the Traction Dept. of the British Thomson-Houston Company, Rugby, England. In 1905 he returned to the Schenectady office of the General Electric Company as Designing Engineer in the Railway Engineering Equipment Department and the Controller Department. Patents covering inventions by Mr. Larzelere were held by both of these companies. For nearly four years he was Assistant Engineer in the office of the Assistant Chief Engineer of the Isthmian Canal Commission, Culebra, Canal Zone, engaged in various engineering problems, particularly in connection with the control of the lock machinery. His return to the General Electric Company's Philadelphia office took place several years ago.

Samuel M. Kennedy, retired Vice-President of the Southern California Edison Company in charge of business development and public relations, died at his home, Alhambra, Calif., July 18. Mr. Kennedy achieved a national reputation in electrical circles by his pioneer work on the subject of public relations, and his authorship of the three publications "The Man in the Street" "Service" and "Winning the Public." He was a native of Toronto, Canada and was graduated from the Upper Canada College in that city. For a time after leaving college, he lived in London, the Resident Manager of a wholesale importing business of which his father was head, but at the early age of 31 his health failed him and he removed to California. In 1900 he became Assistant to the President of the United Electric Power & Gas Company, Los Angeles and when in 1903 this company was absorbed by the Southern California Edison Company, Mr. Kennedy was placed in charge of the Commercial Department. In this office his rare ability to organize and promote progressive methods contributed greatly to the development of his own company's interests and acted as a widely felt stimulus to electrical industry along the entire reach of the Pacific Coast. His articles have appeared frequently in the *Electrical World* and other publications, impressing valuable and well-taken points upon the minds of the executives in industry.

Mr. Kennedy became an Associate of the Institute in 1911 and was transferred to the grade of Member in 1926. Besides his connection with the Southern California Edison Company, he has been Vice-President of the Santa Barabra Suburban Railway and the Pacific Gasoline Company; and a Director of the Alhambra Savings and Commercial Bank. He was a Member of the Electrochemical Society and has also been actively connected with the National Electric Light Association.

Alfred Hutchinson Cowles, inventor and metallurgist and President of the Electric Smelting & Aluminum Company of Sewaren, New Jersey, died at his home August 13, 1929 at 70 years of age. He was a native of Cleveland, Ohio, the son of Edwin Cowles, who founded the *Cleveland Leader* and was later editor of the *Cleveland Evening News*. Mr. Cowles studied electrical science and physics under Professor Mendenhall at Ohio State University in 1876 and 1877. These studies were continued under Professor William Anthony at Cornell University from 1877 to 1882. While at Cornell, Mr. Cowles was a noted crew member—in fact he was one of the crew of four that rowed at Henley, Putney, and Vienna in 1881. After graduating from college, he joined his brother in a prospecting tour into New Mexico, where mining properties which have since proved of great value were opened. In 1881 he visited the Paris Electrical Exhibition. With his brother, Eugene H. Cowles, he developed the first electric furnace in connection with producing aluminum and alloys and the company thus organized erected the first electric furnace in the world, at Lockport, New York, in 1886. Mr. Cowles was one of the inventors of the Cowles process of electric smelting, and due to the development of their electric furnace in addition to aluminum was the production of calcium carbide—now an important commercial factor,—cheaper carbon bisulphide and cheaper phosphorus.

Many honors have been bestowed upon him for his scientific discoveries; he was a member of the American Association for the Advancement of Science and Franklin Institute awarded him the Elliot Cresson Medal and the John Scott Legacy Medal in 1886. In 1889 he was the recipient of the Paris Exposition gold medal. He has been Vice-President of the American Institute of Mining and Metallurgical Engineers, the American and Metallurgical Society of America, the Franklin Institute and Zeta Psi. He joined the Institute in 1886 and was among the first to be elected to the grade of Fellow when it was first adopted by the Institute in 1912. He was also President of the Pecos Copper Company from 1902 to 1918 and Vice-President of the Cleveland Leader Printing Company from 1899 to 1904. Mr. Cowles was also a representative member of the United States Naval Institute.

James T. Hutchings, Vice-President of The United Gas Improvement Company, in charge of engineering development, died suddenly on Saturday, August 17, at Ocean City, N. J., of heart disease.

Mr. Hutchings had returned on August 13 from a two months' trip abroad, and apparently was in his usual health. He had been in his office in The U. G. I. Building until late Friday afternoon, August 16, when he left for the seashore to spend the week-end with his family.

Mr. Hutchings entered the employ of The U. G. I. Company in 1920, as Assistant General Manager. In August, 1921, he became General Manager, and two years later was elected Vice-President in charge of operations. In February 1927 he became Vice-President in charge of engineering development.

Born in Amherst, Mass. in 1889, he attended Amherst public schools and was graduated from Massachusetts Agricultural College with the degree of Bachelor of Science in 1889. His first position after graduating was with the Thomson-Houston Electric Company, of Amherst, with which he remained about four months. In that same year he came to Philadelphia to accept a position as foreman of wiring with the Germantown Electric Company, and later became Superintendent of the West End Electric Company, in which position he remained until that company and numerous other small companies in the city were consolidated into the Philadelphia Electric Company. From 1897 to 1904 he was employed by the latter company as Assistant Electrical Engineer.

Then followed sixteen years with the Rochester Gas and Electric Corporation during which he held the positions of Superintendent of the Electric Department, Assistant Manager, General Manager and President. He capably filled the latter position for two years, until 1920, when he entered U. G. I. employ.

During the World War, Mr. Hutchings was Chairman of the Manufacturers' Committee of the Rochester District in charge of production, and despite the exigencies of that and his regular work, was also power expert for the Ordnance Department in charge of munitions production.

He was a member of the American Gas Association, National Electric Light Association, Engineers Clubs of Philadelphia and New York, the University Club of Philadelphia, and the Overbrook Golf Club. He joined the Institute as an Associate in 1903 and was elected a Member in 1912.

E. B. Craft, wire engineer and head of the Bell Telephone Laboratories since 1922, died at his home in Hackensack, New Jersey, August 20, after suffering from high blood pressue for several months. Mr. Craft was a member of an old American family, the Crafts having come to Massachusetts in 1630. He himself was born in Cortland, Ohio, and was educated in the grade and high schools of Warren, Ohio. His first electrical position, from 1900 to 1902, was as Superintendent of the Lamp Department of the Warren Electrical and Specialty Company. This he gave up to join the Western Electric Company in Chicago, where his first work was editing orders for telephone switchboards. Soon he was placed in charge of making models, and in this capacity he produced his first invention, an indicating device for fuses to protect telephone equipment from electrical disturbances. This proved to be so absolutely correct that it has remained in constant use for the last 23 years. In 1907, with a nucleus from the force he had organized in Chicago, he came to New York as development engineer for the Western Electric Company. Here he began his career as an organizer of development activities, and with a growing need for expansion in the field, his work was rapid. In 1917 he became Assistant Chief Engineer, serving as such for five years, responsible for the development work in the Engineering Department of the Western Electric Company which then operated the works out of which the Bell Telephone Laboratories grew. To the introduction and development of the dial telephone system Mr. Craft contributed not only certain specific inventions but was among the first to appreciate the value of this new method inspiring others with his own faith in its operation. He was also the first to demonstrate the talking motion picture process in 1926 before a meeting of the New York Electrical Society. With the entrance of the United States into the World War, Mr. Craft became a Captain in the Signal Corps, and was promoted to the rank of Major in December 1917. From June to October 1918 he was technical advisor of the United States Navy in London. In 1922 he became Chief Engineer of the Western Electric Company and in 1925 was made Executive Vice-President of the Bell Telephone Laboratories, Inc. At the time of his death, he was a member of the Edison Medal Committee, Chairman of the Library Board, and the Institute's representative to the Newcomen Society. He was Vice-Chairman of the Division of Engineering and Industrial Research of the National Research Council; a member of the Council of the American Institute of Weights and Measures; of the American Society of Automotive Engineers; and a Fellow of the Institute of Radio Engineers. Mr. Craft joined the Institute in 1911 and was elected to the grade of Fellow in 1926.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these Founder Societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES, JULY 1-31, 1929

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

APPLICATIONS DE L'ÉLECTRICITÉ AUX MINES.

By Georges Hacault. Paris, J-B. Baillière et fils, 1929. 552 pp., illus., diagrs., 9 x 6 in., paper. 85 fr.

The author confines himself to electrical hoisting, pumping, ventilating, and air compressing machinery. In this field, he gives a good description of various types of equipment, points out the advantages of each, gives the data necessary for selecting suitable sizes, and directions for testing.

EINFLÜSSE AUF BETON, pt. 1. Ed. 3.

Edited by A. Kleinlogel. Berlin, Wilhelm Ernst & Sohn, 1929. To be complete in 6 or 7 pts. Illus., diagrs., tables, 10 x 7 in., paper. 6.-r. m. each.

A convenient compendium of information upon the chemical and mechanical action of air, water, and chemicals of all kinds upon concrete. The information is in dictionary form, is comprehensive enough for ordinary requirements, and is supplied with references to sources for further details. Methods of preventing action are also given.

ELEKTRISCHE GLEICHRICHTER UND VENTILE.

By A. Güntherschulze. 2d edition. Berlin, Julius Springer, 1929. 330 pp., illus., diagrs., tables, 9 x 6 in., bound. 29.-r. m.

A systematic discussion of electric rectifiers and valves, with special attention to those for currents greater than those encountered in high-frequency work. The physical characteristics, calculation, types and uses are treated. There is a valuable list of German patents in this field and a good bibliography. The new edition is nearly twice the size of the former one, and is practically a new book.

L'ENFANT AND WASHINGTON, 1791-1792.

Edited by Elizabeth S. Kite. (Institute Français de Washington. Historical documents, cahier 3). Balt., Johns Hopkins press, 1929. 182 pp., plate, 11 x 8 in., bound. $3,00.

Here are brought together in chronological order all the existing documents upon L'Enfant's work in planning the city of Washington. They give an interesting picture of his labors, the difficulties with which he met, and the reason for his final dismissal. Ambassador Jusserand's introduction is a fine account of L'Enfant's life.

HOCHDRUCKDAMPF II.

Sonderheft der V. D. I. Zeitschrift. Berlin, V. D. I. Verlag, 1929. 171 pp., illus., diagrs., 12 x 8 in., paper. 6.-r. m.

This volume brings together the more important papers on high-pressure steam which have appeared in the Zeitschrift des Vereinus deutscher Ingenieure during the last five years. The papers discuss a variety of questions connected with the production and use of steam at high pressures, such as modern methods of generation, the influence of high pressures and temperatures upon engine design, and the transformation in industrial practise caused by the introduction of higher pressures.

INTERNATIONAL AIRPORTS.

By Stedman S. Hanks. N. Y., Ronald Press Co., 1929. (Ronald Aeronautic series) 195 pp., illus., 9 x 6 in., cloth. $5.00.

In 1928 the author visited the principal European airports to ascertain what lessons could be learned that would be useful in constructing and managing airports in America. He collected much information upon the layout of these ports, the buildings, the methods of handling traffic, and the other details of air travel. This is presented and compared with American practise.

DAS IT—DIAGRAM DER VERBRENNUNG.

By P. Rosin & R. Fehling. Ber., V. D. I. Verlag 1929. 32 pp., 10 charts, 12 x 8 in., paper. Price not quoted.

Starting with a hitherto unknown relation between the heating value of a fuel and the volume of gas evolved, the author has prepared charts from which the heat capacity of the flue gas can be read off. With these diagrams, it is only necessary to know the heating value of a fuel and the excess of air used to obtain the temperature of combustion, the available heat drop and similar data. The pamphlet explains the theory, illustrates the practical use of the method, and gives diagrams for solid, liquid, and gaseous fuels.

RAILWAYS OF TODAY.

By Cecil J. Allen. London & N. Y. Frederick Warne & Co., 1929. 400 pp., illus., plates, 7 x 6 in., cloth. $5.00.

A popular description of the modern railroad, its equipment, and the way it is operated, with emphasis upon the engineering features. The author writes with skill and understanding, and has compressed a remarkable amount of information into a small volume. English practise is the basis of the account, but variations in other countries are noted. The book is elaborately illustrated with photographic cuts and colored plates.

TRAILS, RAILS & WAR; the LIFE OF GENERAL G. M. DODGE.

By J. R. Perkins. Indianapolis, Bobbs-Merrill Co., 1929. 371 pp., illus., ports., 9 x 6 in., cloth. $5.00.

This work, based on the original documents of General Dodge, and prepared with the assistance of his family, is an authoritative account of his life as a surveyor of western railroad routes, as a military man, and as a promoter of railroads. The story of the building of the Union Pacific, and of the struggles for its control, are told in detail. The book is not only a good biography of a famous engineer, but is also an important contribution to our railroad history.

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contribution from the societies and their individual members who are directly benefited.

Offices:—31 West 39th St., New York, N. Y.,—W V. Brown, Manager.
1216 Engineering Bldg., 205 W. Wacker Drive, Chicago, Ill., A. K. Krauser, Manager.
57 Post St., San Francisco, Calif., N. D. Cook, Manager.

MEN AVAILABLE.—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to **EMPLOYMENT SERVICE, 31 WEST 39th Street, New York City,** *and should be received prior to the 15th day of of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary: temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded. **See also p. 42 of Advertising Section**

POSITIONS OPEN

ELECTRICAL ENGINEER, college graduate, experienced in the design of polyphase induction motors. Opportunity for advancement. Apply by letter. Location, Pacific Coast. X-9031-C-R-2609-S.

RECENT GRADUATE, as part-time instructor who desires to do advance study work. Will be obliged to teach 9 to 10 hours a week, and the balance of the time devote to research or advanced study. Apply by letter. Salary $1200 a year. Location, New York State. X-8980.

ELECTRICAL ENGINEER, about 35, with practical experience in general manufacturing of transformers, motors, switchgear, able to diagnose trouble in repairing of apparatus, full knowledge of mechanical tools and winding necessary. All-round man required to take charge of plants. Apply by letter stating full details with references and salary expected. Opportunity. Location, Western Canada. X-8608-CS.

MEN AVAILABLE

ELECTRICAL ENGINEER, desires position doing research or development work. Thoroughly trained and competent meter engineer. Experienced in combustion and general laboratory and power-plant testing. Have been successful along development lines. Also extensive public utility experience. C-5258.

ELECTRICAL AND MECHANICAL ENGINEER, 31, graduate, single, three years' experience teaching mathematics and electrical engineering laboratory, two years selling, past two years in charge of engineering department of a large manufacturing company which has recently merged with a larger company. C-2697.

PUBLIC UTILITY ENGINEER, age 33, electrical engineering graduate with knowledge of corporation finance and ten years' experience in consulting service on railway, bus, and electric light operation appraisals and public utility regulation problems in major cities throughout the country would like connection with large operator or holding company. B-446.

ELECTRICAL DRAFTSMAN, age 29, six years' experience in the preparation of switchgear engineering wiring diagrams, two years' switchgear test and one year shop wiring. Desires position with an operating company which is permanent and has room for advancement. C-6326.

GRADUATE, 32, married, who has obtained B. S. in electrical engineering work. Speaks Russian (citizen of United States), well acquainted with Manchuria, China. Location, immaterial. C-6290.

MANUFACTURER'S REPRESENTATIVE. Desires to represent several manufacturers of electrical machinery and accessories in India. At present employed in electric power supply company. C-6298.

ELECTRICAL AND MECHANICAL ENGINEERING TEACHER, with five years' teaching experience and two years' design and research experience with large electrical company. Desires position with manufacturer of gasoline or diesel engines. Has had considerable experience in testing of gasoline engines. Good knowledge of German. Member S. A. E. Available on reasonable notice. B-7830.

UNIVERSITY GRADUATE, 35, 15 years', work and sales experience, wishes to represent American firm or firms in British Isles for machinery and apparatus, insulators, materials, etc. Well introduced to largest buyers. Headquarters, London, England, C-6305.

SALES MANAGER, BRANCH SALES MANAGER, OR SALES ENGINEER, 42, married, electrical and mechanical engineer, 18 years' practical experience, design, construction valuation and management of public utilities, and sales of equipment. Location, Middle West or Pacific Coast. C-6327.

ELECTRICAL ENGINEER, graduate, 39, married; executive with extensive Latin-American experience. Capable of taking complete field managerial charge operating, construction, public relations, new business, development work along acquisition lines with public utility or holding company with both domestic and foreign properties. Well acquainted Latin American Government requirements. C-761.

ELECTRICAL ENGINEER, 29, single, recent graduate. Over six years' experience in motor installations and elevator control board mining. Desires position with industrial and construction company. Willing to start low, working knowledge of Russian. Location, immaterial. C-6246.

SYSTEM PLANNING ENGINEER, single, 29, seven years' experience in system planning, tests, calculations, etc. Desires position with broader opportunities, particularly with company just starting system planning. East or Middle West preferred. Available on reasonable notice. C-6303.

RECENT GRADUATE, Electrical Engineer, 1928, desires opportunity with public utility or industrial concern, preferably in preparation for commercial or sales work, and this preferably in the illuminating line. Some public utility experience. Location, Northeast preferred. C-6294.

EFFICIENCY ENGINEER, with over 20 years of practical experience in manufacture and electrical laboratory, desires position in close contact with chief executive and accounting department to establish an original system for developing the personnel efficiency as well as that of the mechanical equipment. C-1867.

ELECTRICAL ENGINEER, 28, married, wishes engineering economic work with utility, consulting engineer, or financial firm. Well trained engineering. economics. Practical experience varied to obtain thorough grounding chosen field. Two years survey, construction, Westinghouse graduate course, one year public utility valuation, two years plant installation, operation, management. Location, United States. C-3082.

ELECTRICAL ENGINEER, B. S. 1921, one year as inspector and assistant research engineer on cables, seven years as electrical designer of substations, power house, oil and copper refineries. Desires position in New York City or Newark, N. J. C-5473.

ELECTRICAL ENGINEER, university graduate, 36. Wide knowledge of electrification including generation, substations, distribution, motor application, control, lighting, etc., as applied to mining, cement mills, and other industries. Experience covers estimates, design and layout, construction and maintenance. Desires to correspond with large industrial concern requiring the services of a man of above qualifications. B-9113.

ELECTRICAL ENGINEER, 20 years' experience on construction work, design and appraisals, as foreman and engineer in charge. At present employed as construction engineer. Available on short notice with best of references. C-6347.

JUNIOR ELECTRICAL ENGINEER, 25, Rensselaer Polytechnic Institute 1926. Three years' experience with large public utility in general and acceptance tests of equipment and materials. In supervisory capacity for the past 18 months. Would like a position in general or electrical engineering or sales with good opportunity for advancement. C-2667.

MEMBERSHIP—Applications, Elections, Transfers, Etc.

RECOMMENDED FOR TRANSFER

The Board of Examiners, at its meeting held July 31, 1929, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grade of Fellow

MONTSINGER, V. M., Research and Development Engineer, General Electric Co., Pittsfield, Mass.

YORKE, GEORGE M., Vice-President in charge of Engineering, Western Union Telegraph Co., New York, N. Y.

To Grade of Member

ALBRECHT, AUGUST H., Electrical Engineer, Standard Oil Co. of Calif., Whittier, Calif.

BARRY, EDWARD J., Electrical Engineer, Perkins Building, Tacoma, Washington.

BOWLES, EDWARD L., Associate Professor, Mass. Inst. of Tech., Cambridge, Mass.

BROKAW, Electrical Engineer, Eastern Oregon Light and Power Co., Baker, Oregon.

CAMPBELL, WALTER W., Manager and Owner, Industrial Electric Service Co., Aberdeen, Wash.

CHANDEYSSON, PIERRE I., President, Chandeysson Elec. Co., St. Louis, Mo.

CHARLEY, REGINALD M., Manager, Transformer Dept., The English Elec. Co. Ltd., Stafford, England.

ERICKSON, JOHN R., Foreman, General Electric Co., Erie, Pa.

ERSKINE, HARRY E., Instructor, Wentworth Institute and Franklin Union, Boston, Mass.

EVANS, WILLARD M., Automatic Control Supervisor, Duquesne Light Co., Pittsburgh, Pa.

FRANKEL, MORTIMER, President, Audiola Radio Co., Chicago, Ill.

HATCH, PHILIP H., Engineer of Automotive Equipment, N. Y., N. H. & H. R. R., New Haven, Conn.

HERZOG, EUGENE, Electrical Test Engineer, State Line Generating Co., Chicago, Ill.

HIGGINS, WARREN S., Teacher, Georgia School of Technology, Atlanta, Ga.

HILL, ARTHUR P., Engineer, Southern Calif. Tel. Co., Los Angeles, Calif.

HOLMGREN, VIKING R., General Electric Co., Lynn, Mass.

HUGHES, CALVIN T., Design Engineer, Conn. Lt. & Pr. Co., Waterbury, Conn.

JANES, LEONARD R., Development Engineer, Public Service Co. of No. Illinois, Chicago, Ill.

KELLY, NICHOLAS J., Chief Engineer of Light and Power, Dept. Water Supply, Gas and Electricity, New York, N. Y.

LEONARD, ALTON W., President, Puget Sound Power & Light Co., Seattle, Wash.

OWENS, THURSTON D., Asst. Prof. of Elec. Engg., Case School of Applied Science, Cleveland, Ohio.

REID, MATTHEW, Resident Electrical Engineer, St. George County Council, Kogarah, Sydney, N. S. W., Australia.

RUTAN, EVERETT J., Supt. Test Dept., New York Edison Co., New York, N. Y.

SCHREGARDUS, W. F., General Plant Supervisor, Southwestern Bell Telephone Co., St. Louis, Mo.

SHAND, ERROL B., Electrical Engineer, Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

SINCLAIR, CARROLL T., Electrical Engineer, Byllesby Engg. & Mgt. Corp., Pittsburgh, Pa.

SMITH, ROBERT C., Chief Civil and Electrical Engineer, Public Service Dept., Glendale, Calif.

STOUT, MELVILLE B., Asst. Prof. of Elec. Engg., University of Michigan, Ann Arbor, Mich.

TURNER, HAROLD L., Asst. Engr., New England Power Co., Boston, Mass.

WADDICOR, HAROLD, Chartered Electrical Engineer, Wembley, England.

WILLS, GEORGE M., General Supt., The Southern Sierras Power Company, Riverside, Calif.

WOOD, LEON F., Toll Fundamental Plan Engr., Northwestern Bell Telephone Co., Des Moines, Iowa.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before September 30, 1929.

Absolon, L. F., Westinghouse Elec. & Mfg. Co., New York, N. Y.
Bacher, J., Brooklyn Edison Co., Brooklyn, N. Y.
Beardsley, W. P., Altoona & Logan Valley Electric Railway Co., Altoona, Pa.
Bellaschi, P. L., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Brewer, N. E., United Electric Service Co., Abilene, Kans.
Cohn, N., Leeds & Northrup Co., Philadelphia, Pa.
Cole, C. M., 1814 Grove St., Berkeley, Calif. (Applicant for re-election.)
Deckman, F. H., Columbia Engineering & Management Corp., Columbus, Ohio
Eich, F. L., Electrical Research Products, Inc., Hollywood, Calif.
Elder, R. W., Edison Electric Illuminating Co. of Boston, Boston, Mass.
Falkenstein, L. F., New York Edison Co., New York, N. Y.
Fernando, K. A., United Electric Light & Power Co., New York, N. Y.
Gieszczykiewicz, S., Chicago Central Station Institute, Chicago, Ill.
Grobe, H. J., New York Electrical Contractors Assn., New York, N. Y.
Higgins, R. E., Western Union Ticker Dept., Los Angeles, Calif.
Hilliard, J. K., (Member), United Artists Studio Corp., Hollywood, Calif.
Johnsen, R. T., Solvay Process Co., Syracuse, N. Y.
Kilmer, T. W., Jr., New York Telephone Co., New York, N. Y.
Kurz, H., Westinghouse Elec. & Mfg. Co., New York, N. Y.
Luedeke, H. A., Western Electric Co., Kearny, N. J.
MacLoskey, J. W., Electrical Testing Laboratories, New York, N. Y.
Mills, G. H., Case School of Applied Science, Cleveland, Ohio
Miskela, E. J., Western Electric Co., Kearny, N. J.
Muehter, M. W., Signal Engineering & Manufacturing Co., New York, N. Y.
Norton, R. H., Southern California Edison Co., Big Creek, Calif.
Pirrung, J. A., Brooklyn Edison Co., Brooklyn, N. Y.
Plant, C., Public Service Electric & Gas Co., Newark, N. J.
Pomeroy, J. G., (Member), U. S. Navy, Bureau of Engineering, Washington, D. C.
Renshaw, D. E., (Member), Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Schmal, C. L., Illinois Testing Laboratories, Inc., Chicago, Ill.
Schug, H. L., Cornell University, Ithaca, N. Y.
Shively, E. K., Union Electric Light & Power Co., St. Louis, Mo.
Stockton, H. M., Dallas Power & Light Co., Dallas, Texas
Swingle, D. R., Hedges, Walsh, Weidner Co., Chattanooga, Tenn.
Terpening, L. H., Fox-Case Corp., New York, N. Y.
Terrell, T. F., (Member), Birmingham Tank Co., North Birmingham, Ala.
Wallace, B. W. Toledo Edison Co., Toledo, Ohio
Weiss, D., Midwest Electric Service, Casper, Wyoming
Total 38.

Foreign

Anschau, J., New South Wales Government Railways & Tramways, Sydney, Australia
Barton, C. A., The Rio de Janiero Tramway Lt. & Pr. Co., Ltd., Rio de Janeiro, Brazil, So. America
Biaus, B. T., Buenos Aires University, Buenos Aires, Argentina, So. America
Chantrill, R. L., British Thomson-Houston Co., Ltd., Willesden, London, Eng.
Fernando, E. A., 112 Gower St., London, W. C. 1, Eng.
Gilbert, W., Bombay Boroda and Central India Railway, Borivlee P. O., India
Payne, C. C., Riegos y Fuerza del Ebro S. A. & Energia Electrica de Cataluna, S. A., Barcelona, Spain
Siebert, T. F., (Member), The Uitenhage Muncipality, Uitenhage, South Africa
White, T. G., Westcliffe Radio Service & Electrical Co., Westcliff-on-Sea, Essex, Eng.
Wright, L. D., Municipal Council of Sydney, Sydney, Australia
Total 10.

STUDENTS ENROLLED

Allen, Henry O., Worcester Polytechnic Institute
Deck, Harold, University of New Mexico
Gross, Morris H., Michigan College of Mining & Technology
Gruber, Norman L., Michigan College of Mining & Technology
Hanlon, Pat. H., University of Notre Dame
Komerska, Frank J., Michigan College of Mining & Technology
Kramer, Howard H., Michigan College of Mining & Technology
Ledesma, Montano C., Engineering School of Milwaukee
Little, George R., University of Southern Calif.
McCanna, F. James, State College of Washington
Nelson, Lewis N., North Dakota Agricultural College
Rowell, Irving H., University of Washington
Sawin, George A., Jr., Harvard University
Sawyer, Charles F., Michigan College of Mining & Technology
Schweitzer, William, Detroit Inst. of Technology
South, Ben J., University of Notre Dame
Stroyny, Ferdynand M. W., Worcester Polytechnic Institute
Thompson, Loren B., Drexel Institute
Vers, Joseph Jr., University of Detroit
Waisanen, Walter F., Michigan College of Mining & Technology
Wyman, Arthur W., Northeastern University
Yeomans, Richard H., McGill University
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*Carl Hering, 1900-1.	A. W. Berresford, 1920-21.
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Bion J. Arnold, 1903-4.	Harris J. Ryan, 1923-24.
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*Samuel Sheldon, 1906-7.	C. C. Chesney, 1926-27.
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*Deceased.	R. F. Schuchardt, 1928-29.

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A. M. Candy, Chairman, Westinghouse E. & M. Co., East Pittsburgh, Pa.
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NEW CATALOGUES AND OTHER PUBLICATIONS

Mailed to interested readers by issuing companies

Park Cable.—Bulletin, 12 pp. Describes "Condex" park cable for use in underground systems of distribution. Simplex Wire & Cable Co., Boston, Mass.

Pipe Fittings.—Bulletin 70. Describes the Delta-Star drop forged "Uniclamp" pipe fittings, a radically new type of fitting comprising five parts from which innumerable combinations can be assembled in the field. Delta-Star Electric Company, 2400 Block, Fulton Street, Chicago, Ill.

Motors.—Bulletin 159, 4 pp. Describes Wagner large vertical motors covering all types in ratings of 1½ to 30 horsepower. Wagner Electric Corporation, 6400 Plymouth Street, St. Louis, Mo.

Choke Coils.—Bulletin 23, 8 pp. Describes Pacific Electric Type C choke coils, insulator mounted and suspension types. Pacific Electric Manufacturing Corp., 5815 Third St., San Francisco, Cal.

Mine Locomotives.—Bulletin 1841, 26 pp. Describes the various types of Baldwin-Westinghouse mine and industrial locomotives. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Meters.—Bulletin 73 Addenda, 4 pp. Describes narrow-type HN switchboard meters for alternating current, designed for maximum utilization of space without sacrifice of either performance or appearance. Sangamo Electric Company, Springfield, Ill.

Current Transformers.—Bulletin 25, 4 pp. Describes Pacific Electric neutral current transformers for residual relays on grounded neutral systems. Characteristics and applications of these instruments are shown. Pacific Electric Manufacturing Corp., 5815 Third St., San Francisco, Cal.

Controllers.—Bulletin 114, 8 pp. Describes Monitor automatic, brake-stop, printing press controllers intended for application to alternating-current, slip-ring motors. The Monitor Controller Co., 55 E. Gay St., Baltimore, Md.

Electric Heat for Industry.—Bulletin, 34 pp. This booklet was compiled by the Public Service Company of Northern Illinois, 72 West Adams St., Chicago, for the education of its customers on electric heat and its industrial application.

Oil Purifiers.—Bulletin 20240-C, 4 pp. Describes Sharples Super Centrifuge oil purifiers. The capacity of the units ranges from 180 to 1200 gallons. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

Circuit Breakers.—Bulletin C-1852, 8 pp. Describes types F-24 and F-24-R oil circuit breakers with current ratings of 400, 600 and 800 amperes at operating voltages of 15,000 or less. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Groundometers.—Bulletin 110, 12 pp. Describes the "Groundometer," a modified Wheatstone bridge designed particularly for measuring the resistance of earth electrodes. The Borden Electric Co., 480 Broad St., Newark, N. J.

Electrical Maintenance Equipment.—Catalog 14, 44 pp. Describes the complete line of Martindale electrical maintenance equipment, including undercutting and slotting devices, commutator stones, blowers, sprayers, insulation meters, circuit testers, etc. The Martindale Electric Company, 1260 West 4th Street, Cleveland, O.

Meters.—Bulletin C-1753-A "Registers of Revenue," 12 pp. The requisites of a good watthour meter and its construction are explained, and a short discussion on the origin and history of the watthour meter is included. "OB" meters, portable meters and remote control meters with equipment are described. The need of subdivided metering is discussed with the aid of charts. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

NOTES OF THE INDUSTRY

The Champion Switch Company, Kenova, West Va., are adding 10,000 feet of floor space to their switch assembly department to take care of increasing demands for this equipment. The New York office of the Company has been moved from 2 Rector Street to 140 Cedar Street, where increased space and facilities have been secured.

Wagner Electric Organization Changes.—The Wagner Electric Corporation of St. Louis, announces the transfer of F. C. Hosimer from the St. Louis home office to the Chicago branch sales office. Ralph R. Rugheimer is now a member of the Atlanta branch sales office. The Cleveland service station and branch sales office has been moved to a new building at 3756 Carnegie Avenue.

Another Large Unit for Brooklyn Edison.—An order has been placed with the Westinghouse Electric & Manufacturing Company for a 110,000 kw. generating unit consisting of steam turbine, condensing equipment and electric generator to be installed as the sixth unit in the Brooklyn Edison Company's Hudson Avenue Station. It is expected that the new equipment will be ready for operation in the spring of 1931. With this installation, the capacity of the Hudson Avenue Station will be 450,000 kw. When completed the station will have eight generating units with a total capacity in excess of 1,000,000 horsepower.

General Electric Consolidates Supply Companies.—Effective October 1, 1929, the fourteen wholesale distributing corporations owned by the General Electric Company will be consolidated into the General Electric Supply Corporation (of Delaware). These companies have for many years distributed General Electric products and the plan involves no change of ownership. The consolidated corporation will be in a much better position to offer nation-wide service through its ability to give service from any one of the seventy-six houses, through interchangeability of stocks, and speedier and more economical operation.

Changes in Allis-Chalmers Organization.—J. R. Jeffrey, manager of the electrical department of the Allis-Chalmers Manufacturing Company, Milwaukee, has resigned and is retiring after twenty-eight years' service with the company. During his connection with the electrical department it has grown from a small beginning to one of the largest departments of the company. R. S. Fleshiem succeeds Mr. Jeffrey. He has been with the company since 1919 as assistant manager of the electrical department. L. W. Grothaus, assistant manager of the electrical department has been transferred from the company's Bullock Works at Norwood, O., to Milwaukee, succeeding Mr. Fleshiem. C. J. Rattermann has been appointed assistant manager of the electrical department and will be located at the Norwood plant. W. G. May has been appointed manager of the Cincinnati district office, located in the First National Bank Building.

A New Wire Producer.—George A. Jacobs, founder and former president of the Dudlo Manufacturing Company, and his associates, have organized the Inca Manufacturing Corporation at Fort Wayne, Indiana, to manufacture copper wire products for electric, radio, automotive and kindred industries, specializing in magnet wire and windings. Offices have already been established and construction of a mammoth plant is well under way on the eleven-acre factory site purchased. It is expected to have the plant in operation in actual production within the next few weeks. The first unit of the factory covers an area of 200 by 300 feet, and will afford immediate employment for 500 workers. It is planned to establish another large factory unit at Los Angeles, California, later. Officers of the new company are: George A. Jacobs, president; Wendell C. Glass, vice-president; George W. Spindler, secretary-treasurer and S. A. Jacobs, in charge of sales.

JOURNAL OF THE A I E. E.

DEVOTED TO THE ADVANCEMENT OF THE THEORY AND PRACTISE OF ELECTRICAL ENGINEERING AND THE ALLIED ARTS AND SCIENCES

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A Message From the President.

The Inter-relationship of the Branch and the Student Member

THE one hundred College Branches of the American Institute of Electrical Engineers are so many laboratories located by the Institute at various engineering colleges of the United States to serve in the training of prospective engineers. They are not laboratories where circuits, instruments, and electrical machinery and systems are dealt with exclusively, but rather are they laboratories where elements of management, organization, leadership, and the ability of the Student to express himself before his fellows in good English are important. They are intended as a help in training young men toward that part of a definition of engineering, "the art of organizing and directing men," as well as in the acquisition of technical knowledge. The Branches are of advantage to the college, to the Student Member, and to the Institute; to the college they serve to develop an important element in the training by the laboratory method, to the Student Member they offer *experience*, and the Institute welcomes to its Associate membership, and prospective membership, those college graduates who, meeting its requirements have had two or more years' training as Student Members in Branch organization and work. Student Members are that much sooner ready to take up the duties of Section membership after graduation.

As pointed out in the August issue of the Journal, it is *experience* in the actual conduct of the affairs of the Institute that is important to enable one to fulfill his obligation to his profession. The Branch offers that experience to the Student Member at the earliest possible opportunity and the Student Member who avails himself of the opportunity is earliest in a position to meet such obligation and to further advance himself in his chosen profession.

The object of the Branch being to offer experience to the Student Member in the conduct of affairs of the Institute, and the object of the Student Member being to acquire such experience, it is of mutual advantage to have the activities of the Branch conducted as fully as possible by its Student membership. This naturally comes through service,—service on committees, in the presentation of papers, in pertinent discussion, as an officer or delegate to conventions, etc. Each Student Member should find a useful place for himself in his Branch.

A fruitful stimulus to the Branch often comes from an occasional address by an older member of the Institute, in a joint meeting with a Section, in a convention, in an electrical show, some social function, or a trip to important engineering work, but it is believed that the primary purpose of the Branch is *experience* for the Student Member however obtained.

Especially is it urged that the college student should recognize, in joining his Branch and becoming a Student Member of the American Institute of Electrical Engineers, that he has become a member of his national professional society and also that he be so recognized by others. By that act he has affiliated himself with a great professional organization with which, in its several successive grades, he may hope to continue for life. It is a dignified and appropriate step for him to take during his college days and worthy of all respect as indicating a serious purpose in life.

Harold B. Smith

President

Some Leaders of the A. I. E. E.

Wm. A. Del Mar, Chief Engineer of the Habirshaw Cable and Wire Corporation since 1917, was born at San Francisco, California, December 15, 1880. His father, then a well-known mining engineer, retired in 1887 and took his family to Europe in order that he might indulge his hobby of historical and archaeological research. This led to the son's being brought up in an atmosphere of research, and receiving most of his education in Paris and London, in which latter city he was graduated as electrical engineer from the City and Guilds College, in 1900. During his last year at college, Mr. Del Mar assisted W. B. Duddell and Mrs. Ayeton in their classic work on the carbon arc, during the course of which the oscillograph and thermo-galvanometer were developed.

Returning to America, Mr. Del Mar spent a year at Schenectady and then entered the electric traction field in New York City, being successively associated with the electrifications of the Manhattan elevated (1902-1904), the New York Central Terminal (1904-1915), and the Interborough subways (1915-1917).

In his capacity of Technical Assistant in the organization headed by the late Edwin B. Katte, Mr. Del Mar designed the basic features of the transmission and distribution systems for the New York suburban zone, and made economic studies of electrifications for various other divisions of the New York Central Lines.

This work attracted the attention of the late H. G. Stott, then in charge of the electric power supply for the Interborough Rapid Transit Co., and in 1915 Mr. Del Mar was engaged to develop a composite transmission and distribution for the entire system, including existing and projected subways, elevated lines, and surface railways. This work was completed in 1917 and Mr. Del Mar, whose special interest had long been in wire and cable problems, became associated with the Habirshaw Electric Cable Co. as Chief Engineer.

So active was this interest in the early days of his railroad career that in 1909 he published a book on the subject entitled "Electric Power Conductors." While writing this book he became keenly aware of the lack of standards in the wire and cable field and started a movement which culminated in the present A. I. E. E. Wire and Cable Standards which were prepared by committees under his chairmanship. In 1911 Mr. Del Mar organized and headed the Joint Rubber Insulation Committee which developed the present standard method of chemical analysis for rubber compounds.

Mr. Del Mar's interest in electrical standardization has been keen and active in many lines. He has been a member of the Standards Committee of the A. I. E. E. since 1913, and has served for many years on the American Committee of the International Electrotechnical Commission. He is now Chairman of the A. S. A. Sectional Committee on Insulated Wires and Cables, sponsored by ten technical and industrial societies.

Mr. Del Mar served as a Manager of the Institute 1917-21 and was the first Vice-President for the New York District to be elected under the regional plan 1921-22. He has also served on several of the Institute's technical committees, and on committees of other technical societies, including the N. E. L. A., A. S. T. M., A. E. R. A., Insulated Power Cable Engineers' Assn. and Assn. of Railway Electrical Engineers.

The Habirshaw Electric Cable Co. was one of the oldest firms in its line and Mr. Del Mar's engagement was part of a very extensive program of rehabilitation and modernization undertaken by a new management. The most important task was the creation of a modern research laboratory. Here, beginning in 1918, pioneer work was done on stresses in cables, dielectric loss, paper density, vacuum formation in cables, etc., much of which has been described in Institute papers and discussions since 1919. A paper on *Vacua in High-Tension Cables*, which gave an explanation of how a number of sound lengths of cable, when joined together, might give an unsound line, has had a marked influence on the design of high-tension cable lines.

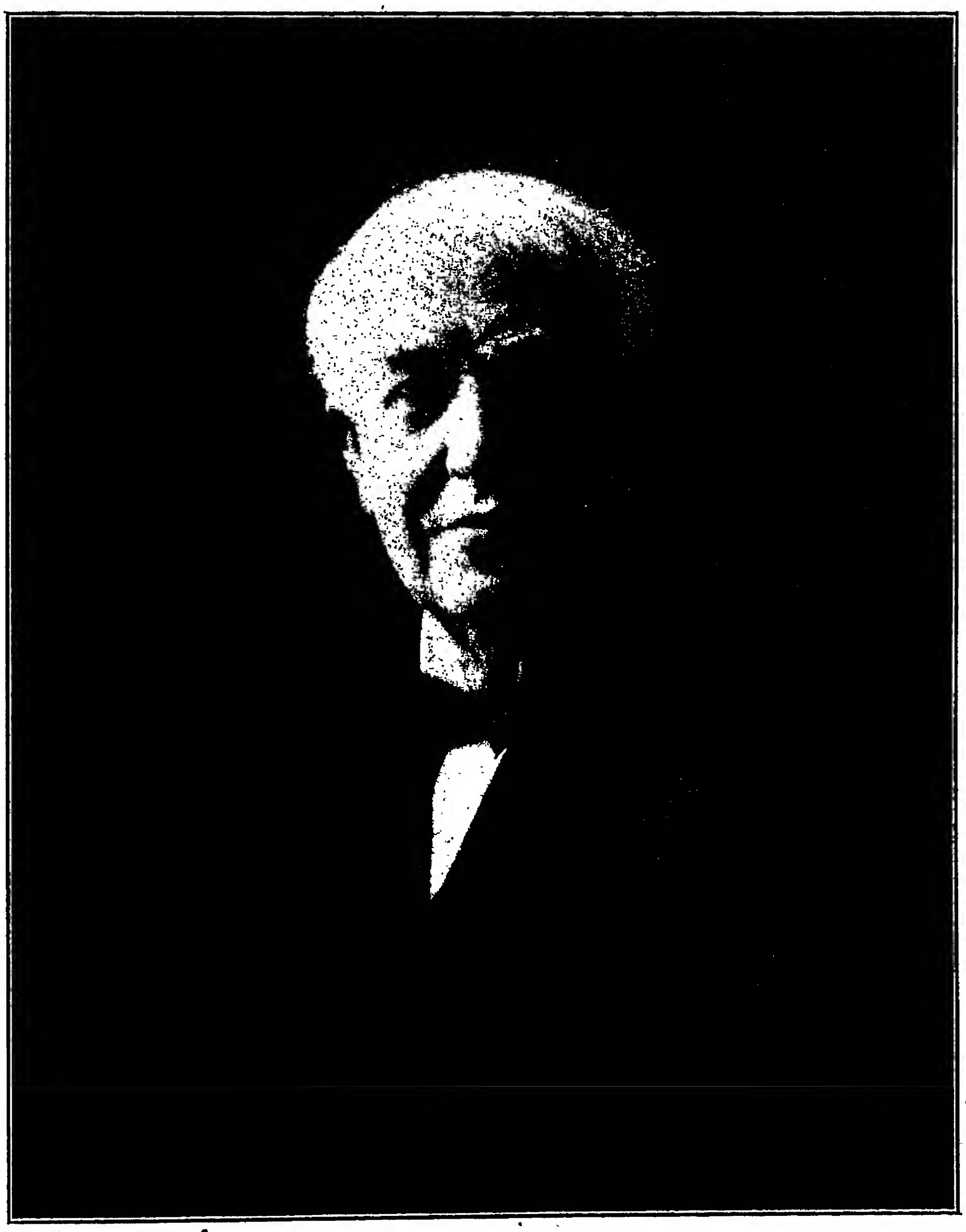
During the War, the wire and cable industry was worked to capacity producing supplies for the Army and Navy and Mr. Del Mar's time was taken up with the special problems that arose from this condition. He found time, however, to organize and act as chairman of a committee appointed by the A. I. E. E. to assist the War and Navy Departments in their cable problems, especially those relating to the new electrically-driven battleships. After the War, there developed out of this committee an important peace-time activity, the Insulation Committee of the National Research Council, of which Mr. Del Mar is Vice-Chairman. He was also member of a War Committee created by the Founder Societies to find technical experts for the government.

During 1923-24 Mr. Del Mar gave a course of lectures on cables at the University of Pennsylvania and had the lecture notes published in book form under the title, "Electric Cables." He is also Associate Editor-in-Chief of Pender's Handbook and is an Associate Editor of Merriman's American Civil Engineer's Pocket Book.

Mr. Del Mar's interests are not all technical, however. Music is one of his hobbies and in 1927 he organized a symphony orchestra in his home town, Greenwich, Conn. where he is President of the local Musical Arts Society. Mr. Del Mar became an Associate of the Institute in 1906, and was transferred to the grade of Fellow in 1920.

His contributions to Institute's literature have been numerous, as an author of individual papers, a joint author and as a discussor of papers presented by others in his field of interest. The latest of these contributions was a paper presented at the Summer Convention at Detroit,—*Electric Strength of Solid and Liquid Dielectrics*, in a co-authorship with R. H. Marvin, Research Assistant of Johns Hopkins University and W. F. Davidson, Director of Research, the Brooklyn Edison Company.

Lights' Golden Jubilee



THOMAS A. EDISON

TO Thomas Alva Edison the members of the American Institute of Electrical Engineers are doubly indebted.

We have, of course, shared with the rest of humanity the economic and social benefits resulting from his perfection of a practical system of lighting with the incandescent electric lamp. But more than that, the field of activity with which we are so closely associated in our every day life, has been immeasurably advanced in usefulness through the rare combination of inventive genius and business ability that exists so happily in this man.

Through him we find today an increased opportunity to make electricity serve mankind, and for this we should be especially appreciative of the tireless energy and inexhaustible ingenuity that produced the system of electric lighting of which we now celebrate the fiftieth anniversary.

HAROLD B. SMITH, President.

Nomination of Officers of the A. I. E. E.

The actions specified in the Institute's Constitution and By-laws relative to the organization of a National Nominating Committee are being taken, and the meeting of the National Nominating Committee for the nomination of officers to be voted upon at the election in the Spring of 1930 will be held between November 15 and December 15. All suggestions for the consideration of the National Nominating Committee must be received by the Secretary of the Committee at Institute Headquarters, New York, not later than November 15.

The sections of the Constitution and By-laws governing these matters are quoted below:

CONSTITUTION

28. There shall be constituted each year a National Nominating Committee consisting of one representative of each geographical district, elected by its Executive Committee, and other members chosen by and from the Board of Directors not exceeding in number the number of geographical districts; all to be selected when and as provided in the By-laws; The National Secretary of the INSTITUTE shall be the Secretary of the National Nominating Committee, without voting power.

29. The executive committee of each geographical district shall act as a nominating committee of the candidate for election as vice-president of that district, or for filling a vacancy in such office for an unexpired term, whenever a vacancy occurs.

30. The National Nominating Committee shall receive such suggestions and proposals as any member or group of members may desire to offer, such suggestions being sent to the secretary of the committee.

The National Nominating Committee shall name on or before December 15 of each year, one or more candidates for president, treasurer and the proper number of managers, and shall include in its ticket such candidates for vice-presidents as have been named by the nominating committees of the respective geographical districts, if received by the National Nominating Committee when and as provided in the By-laws; otherwise the National Nominating Committee shall nominate one or more candidates for vice-president(s) from the district(s) concerned.

BY-LAWS

SEC. 22. During September of each year, the Secretary of the National Nominating Committee shall notify the chairman of the Executive Committee of each geographical district that by November 1st of that year the executive committee of each district must select a member of that district to serve as a member of the National Nominating Committee and shall, by November 1st, notify the Secretary of the National Nominating Committee of the name of the member selected.

During September of each year, the Secretary of the National Nominating Committee shall notify the Chairman of the Executive Committee of each geographical district in which there is or will be during the year a vacancy in the office of vice-president, that by November 15th of that year a nomination for a vice-president from that district, made by the district executive committee, must be in the hands of the Secretary of the National Nominating Committee.

Between October 1st and November 15th of each year, the Board of Directors shall choose five of its members to serve on the National Nominating Committee and shall notify the secretary of that committee of the names so selected, and shall also notify the five members selected.

The Secretary of the National Nominating Committee shall give the fifteen members so selected not less than ten days' notice of the first meeting of the committee, which shall be held not later than December 15th. At this meeting, the committee shall elect a chairman and shall proceed to make up a ticket of nominees for the offices to be filled at the next election. All suggestions to be considered by the National Nominating Committee must be received by the secretary of the committee by November 15th. The nominations as made by the National Nominating Committee shall be published in the January issue of the A. I. E. E. JOURNAL, or otherwise mailed to the INSTITUTE membership during the month of January.

F. L. HUTCHINSON,
National Secretary

October 1, 1929

New Sources of Energy Still Sought

Conservative individuals have a strong tendency to greet with loud cries and derisive laughter each new method of power generation and application which their more imaginative fellows envision. While Fulton was the jest of "little old New York" the *Clermont* was about to accomplish the definitely "impossible." While Edison devised amazingly clumsy devices for the use of electrical energy as reactionaries scoffed, the electrification of America was embryonically on its way. Again, Elwood Haynes and the Wrights were quite mad. Any normal person of thirty or forty years ago knew that.

The skeptics offer excellent reasons, in fine logical style, to explain just why the dream of Georges Claude to generate power from sea water by vapor turbines in the Tropics must go aglimmering, but M. Claude first generates the power practically on a small scale under unfavorable conditions and then courageously starts to build a large plant—12,000 kw.—to prove that the-thing-that-could-not-be-done is no fool's fantasy.

Latest among the torturers of mossbackery is the gentleman who would utilize the electrical energy developed in the photochemical cell, upon alternate exposure to and protection from sunlight, for the useful accumulation and transformation of sun energy for the needs of mankind. The recognized difficulties of small reaction velocities, with consequent low intensity of electrical current, are not insurmountable; for, as pointed out by Prof. F. M. Jaeger, the construction of such cells is wholly a problem of reaction kinetics, and if it should prove possible to devise radiation accumulators in which reversible and very rapid photochemical changes take place, the problem of using solar radiation as a source of energy might be solved.

One fine day humanity will awake to find that the difficulties of transforming solar energy into an economical, continuous and reliable source of supply by one means or another, but without the unconscionable delay of "natural" chemical and physical processes, have yielded to persistence—and a new era will be upon the world. The only impossible things are those which have not as yet been accomplished.—*Electrical World.*

Abridgment of

Traveling Waves Due to Lightning

BY L. V. BEWLEY*

Associate, A. I. E. E.

Synopsis.—*The purpose of this paper is to describe and analyze the origin and formation of traveling waves on a transmission line induced by lightning discharges, and to investigate their behavior at a transitional point where there is an abrupt change of circuit constants. Some of the ground covered is necessarily old and well-known, but has been included in the interests of completeness and continuity of treatment. The effect of the rate of cloud discharge and the initial distribution of bound charge on the shape and amplitudes of the traveling waves is brought out. General methods of analysis are formulated and illustrated by practical cases. The assumptions and approximations involved are discussed, and the probable direction of their deviation from fact indicated. Exact and approximate mathematical expressions are derived, and therefrom graphical and tabular methods are outlined. For all of the examples given, line attenuation and distortion are neglected and only the first reflection from a transition point is considered.*

I. Introduction

THIS paper, which deals particularly with the mathematical study of the formation and propagation of lightning waves on transmission lines, is part of an extensive investigation of lightning which has been under way for a number of years under the general direction of F. W. Peek, Jr. Other papers of this series, covering laboratory and field studies as well as the effect of lightning on apparatus, have already been presented.[1, 2, 3] While this paper deals essentially with a mathematical analysis of the subject, it has been written in such a way that it is not felt necessary for the reader to go into the mathematics to obtain a knowledge of the results. Such practical aspects as the effects of series induction coils, extra ground wires, etc., on transmission lines are analyzed mathematically and discussed.

II. Origin of Traveling Waves Due to Lightning

When a charged cloud approaches a transmission line, a charge of opposite sign leaks over the insulators and appears on the line as a bound charge fixed in position by the electrostatic field of the cloud.

The corresponding potential distribution when this charge is instantaneously released is quite independent of the variation of capacitance, and is $V = h\,G$.

Measurements by Peek indicate maximum gradients of the order of 100 kv. per foot for heights above ground of the order of a transmission line. However, so far as the author knows, no data are available as to the intensification of the field (if it occurs) during the preliminary or incipient stages of a cloud discharge. Measurements taken on short antennas are not informative.

If the preliminary stages of a cloud discharge are completed within 100 microseconds or so, the time is not sufficient for additional bound charge to leak over the insulators.

The measurements taken by Peek[1] on short antennas indicate that the final release of the bound charge sometimes takes place in one or two microseconds. Probably much longer periods may occur, but as shown from the theoretical considerations discussed later, these

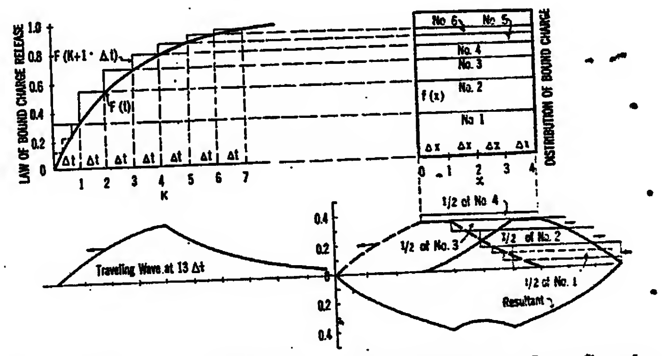


FIG. 2—GRAPHICAL METHOD FOR DETERMINING WAVE SHAPES

slower rates of cloud discharge cannot give rise to excessive potentials. Physically, a finite rate of cloud discharge is equivalent to the release of the bound charge by small steps (see Fig. 2) which, in the limit, coincide with the smooth curve of cloud discharge rate. Each of these blocks forms in succession and immediately begins to move away as traveling waves. But if the time of release is slow enough, some of the blocks first formed have completely passed out from under the original distribution before all of the bound charge has been released, with the result that only part of the total number of blocks will overlap and add up by superposition.

Experimental data on the functional rate of cloud discharge are not available. For a strictly mathematical study, only the most simple expressions can be handled, but the graphical and tabular methods

*General Transformer Engineering Department, General Electrical Company, Pittsfield, Mass.

Complete copies upon request.

1. *Lightning—Progress in Lightning Research in the Field and in the Laboratory*, F. W. Peek, Jr., A. I. E. E. Quarterly TRANS., Vol. 48, April 1929, p. 436.

2. *Effect of Transient Voltages on Power Transformer Design*, K. K. Palueff, A. I. E. E. Quarterly TRANS., July 1929, p. 681.

3. *Lightning Studies of Transformers by the Cathode Ray Oscillograph*, F. F. Brand and K. K. Palueff, A. I. E. E. Quarterly TRANS., July 1929, p. 998.

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described elsewhere in this paper are applicable to any rate of cloud discharge which can be drawn as a curve on a piece of paper. The illustrations included are for exponential and straight line discharges. The in- influence of the function $F(t)$, expressing the law of release of the bound charge on the shape of the resulting traveling waves is shown in Fig. 3. If $f(x)$ represents the distribution of bound charge, then the curves A, B, and C represent the shape of the traveling waves corresponding to the cloud discharging in the same time t; but according to different laws a, b, and c.

The crest values, shapes and lengths of traveling waves depend upon the intitial distribution of bound charge, but to an even greater extent, on the rate of cloud discharge. Fig. 5 shows a set of traveling waves developed from rectangular distributions of bound charge of 1000-, 2000-, 3000- and 4000-ft. lengths, and released according to the law $(1 - \epsilon^{-a t})$; so that the cloud discharge was 95 per cent completed in 1, 2, 3, and

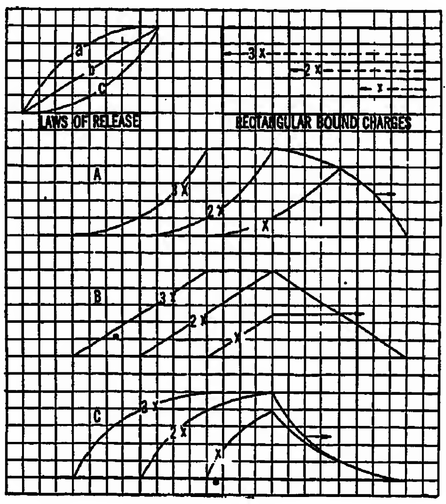

FIG. 3—EFFECT OF THE LAW OF DISCHARGE ON THE SHAPE OF TRAVELING WAVES

4 microseconds. The slower the rate of discharge, the lower the crests and the longer the wave. This is a necessary consequence of the fact that all waves originating from a given bound charge must contain exactly the same energy (neglecting line losses) regardless of the rate at which that charge is released. Thus a decrease in crest values must be compensated for by an increase of length. The length of the wave expressed in microseconds (one microsecond being equal to 1000 ft. of wave travel) is roughly equal to that of the bound charge plus the number of microseconds required for the cloud discharge. The faster the rate of discharge the steeper the wave front. The crest values depend on the bound charge distribution and the rate of its release.

4. "Lightning," F. W. Peek, Jr., *Journal Franklin Inst.*, Feb. 1925.

They are:[1–4]

$$\text{Crest of traveling wave} = \alpha' G h$$
$$\text{Maximum potential} = \alpha G h$$

The factors α and α' corresponding to peaked distributions and exponential release, are shown in Fig. 7. It will be noticed that 100 per cent potential ($\alpha = 1.0$, $\alpha' = 0.5$) occurs only for an instantaneous discharge, or

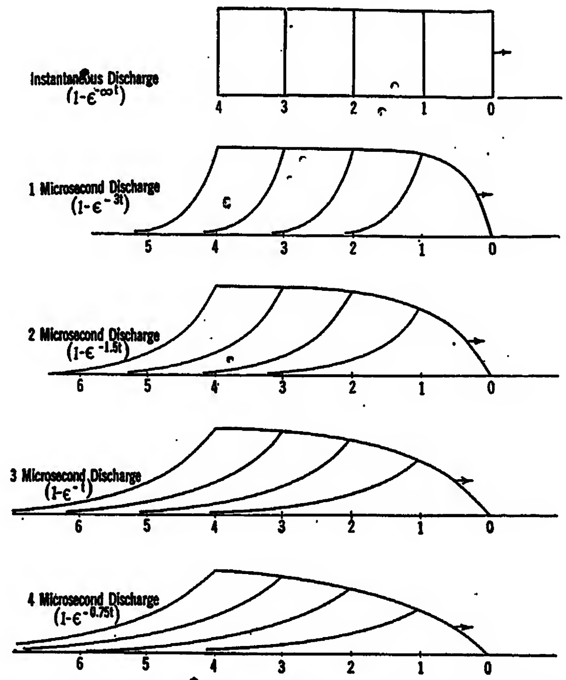

FIG. 5—TRAVELING WAVES FROM RECTANGULAR DISTRIBUTION OF BOUND CHARGE

for very long clouds, and falls off rapidly as the time of release is increased, or the length of the cloud shortened. An interesting point is that ultimately the maximum

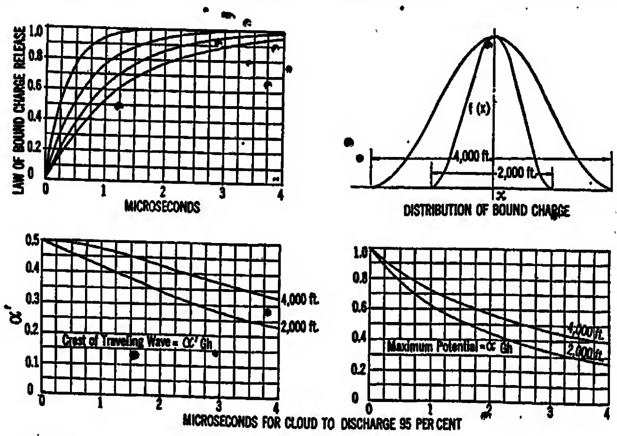

FIG. 7—INFLUENCE OF THE RATE OF DISCHARGE AND LENGTH OF CHARGE ON THE VOLTAGE CRESTS

potential and the crest of the traveling wave have the same value.

Fig. 9 shows the actual wave shapes, and the maximum potential at any instant after the beginning of discharge for a given bound charge released at different rates.

Fig. 11 shows the formation of traveling waves at different stages of their development. This particular set originated from the 2000-ft. peaked bound charge distribution of Fig. 10, released in one microsecond. During the first half microsecond or so, the traveling waves have not fully formed, but are moving out and spreading apart at the same time that they increase in magnitude. Eventually, however, the moving wave

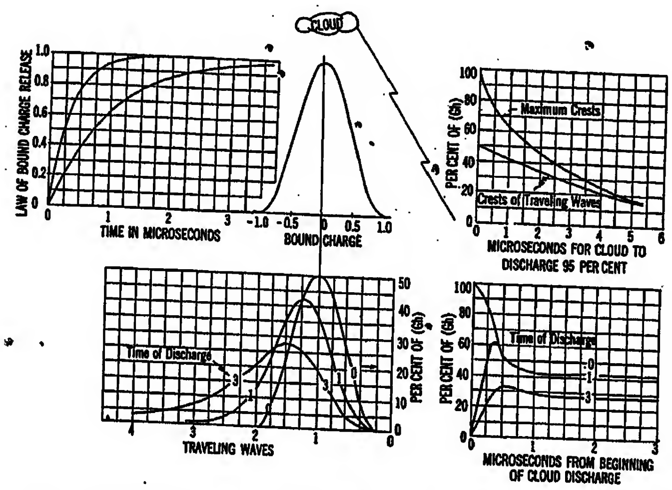

Fig. 9—Wave Shapes Derived from Peaked Bound Charge Released at Different Rates

crests can be distinguished as they separate out and acquire identity. It is because of this simultaneous growth and separation, that the maximum potential is less than twice that of the traveling wave crests, and it is because of the spreading action that the crests are always less than they would be for an instantaneous cloud discharge.

The mathematical work associated with the foregoing is given in the complete copy of the paper.

Traveling Waves Induced by Lightning

The sudden release of a bound charge distributed as $2\,C\,f\,(x)$ initiates a pair of exactly similar forward and reverse traveling waves having the same shape, but one-half the amplitude, of the potential corresponding to the fixed distribution of bound charge. The equations for the traveling waves under the conditions of instantaneous cloud discharge, and up until the instant when a transition point is reached, are therefore

$$e = f\,(x + v\,t) + f\,(x - v\,t) \tag{22}$$

$$i = \sqrt{\frac{C}{L}}\,\{\,f\,(x + v\,t) - f\,(x - v\,t)\,\} \tag{23}$$

If the cloud discharge is not instantaneous

$$e = \int_0^t \{\,f\,[x + v\,(t - \tau)] + f\,[x - v\,(t - \tau)]\}\,\frac{\partial F\,(\tau)}{\partial\,\tau}\,d\,\tau$$

$$= \lim_{\Delta t \to 0} \sum_{\kappa=0}^{n} \{f\,[x + v\,(n - \kappa)\,\Delta\,t] + f\,[x - v(n - \kappa)\,\Delta\,t]\}$$

$$\{\,F\,[(\kappa + 1)\,.\,\Delta\,t] - F\,[\kappa\,.\,\Delta\,t]\} \tag{25}$$

where $n\,.\,\Delta\,t = t$, $\kappa\,.\,\Delta\,t = \tau$, and $F\,(t)$ is the time function by which the bound charge is released.

The application of the integral in equation (25) is limited to analytic expressions for f and F whose integrals in the above combinations are known. But the summation, the limiting case of which is the exact solution, is immediately applicable to any functions f and F whose graphs are known or assumed. Ultimately, since both of these functions must be found from experimental data, it is advisable to deal directly with the finite summation as an approximation of arbitrary exactness. From it, both graphical and tabular methods can be developed.

Empirical Equation for Approximate Wave Shape. The combined influence of the initial distribution of bound charge and the rate of cloud discharge, imparts to the traveling waves a characteristic shape. The shapes obtained by the previous analysis check those which have been measured in the field and in the laboratory. An empirical equation which represents this characteristic shape quite accurately, and at the same time is remarkably simple for analytic purposes, is given by

$$e = E\,(\epsilon^{-a\lambda} - \epsilon^{-b\lambda}) \quad \text{for } t > 0. \tag{26}$$

As special cases of this equation there are the various wave shapes illustrated in Fig. 12.

Behavior of a Traveling Wave at a Transition Point. When a traveling wave reaches a transition point at which there is an abrupt change of circuit constants, as an open or short-circuited terminal, or a junction with another line, etc., a part of the wave is reflected back, and a part may pass on to other sections of the circuit. The impinging wave is called an *incident* wave, and the two waves to which it gives rise at a transition point are

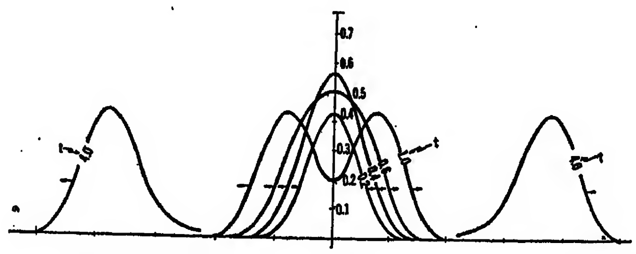

Fig. 11—Formation of Traveling Waves

called the *reflected* and *transmitted* waves respectively.

Suppose that the line is closed at the transition point by a general impedance consisting of any arrangement of inductances, resistances, capacitances, and other lines. Let the differential equation specifying this general impedance be written as $Z_0\,(p)$. Let the transition point be taken as the origin of coordinates, and distance along the line away from the point be counted as posi-

tive, so that an approaching wave is traveling in the negative direction. By equation (14) the potential and current incident waves will have the same sign. Denote the incident waves by (e) and (i), the reflected waves by (e') and (i'), and the transmitted waves, if they exist, by (e'') and (i''). Then the potential at the transition point is, using (14),

$$e_0 = e + e' = (i + i')\, Z_0\,(p) = (e - e')\, Y\, Z_0\,(p) \qquad (29)$$

where $\quad Y = 1/Z = \sqrt{C/L}$ = surge admittance.

Solving this equation for e' there is

$$e' = \frac{Z_0\,(p) - Z}{Z_0\,(p) + Z}\, e = \text{reflected potential wave} \qquad (30)$$

The total resultant wave at the transition point is the sum of the incident and reflected waves,

$$e_0 = e + e' = \frac{2\, Z_0\,(p)}{Z_0\,(p) + Z}\, e$$

$$i = i + i' = Y\,(e - e') = \frac{2}{Z_0\,(p) + Z}\, e \qquad (31)$$

In general $Z_0\,(p)$ may consist of any number of branches in parallel. If one of these branches consists of another line of surge impedance Z_2 connected through a concentrated impedance network $Z_m\,(p)$, then the potential wave transmitted through this impedance to the line is

$$e'' = e_0 - Z_m\,(p)\, i'' = e_0 - Z_m\,(p)\, \frac{e_0}{Z_m\,(p) + Z_2}$$

$$= \left[1 - \frac{Z_m\,(p)}{Z_m\,(p) + Z_2} \right] e_0$$

$$= \left[\frac{Z_2}{Z_m\,(p) + Z_2} \right] \left[\frac{2\, Z_0\,(p)}{Z_0\,(p) + Z} \right] e \qquad (32)$$

Thus, if e is known at the transition point as a function of

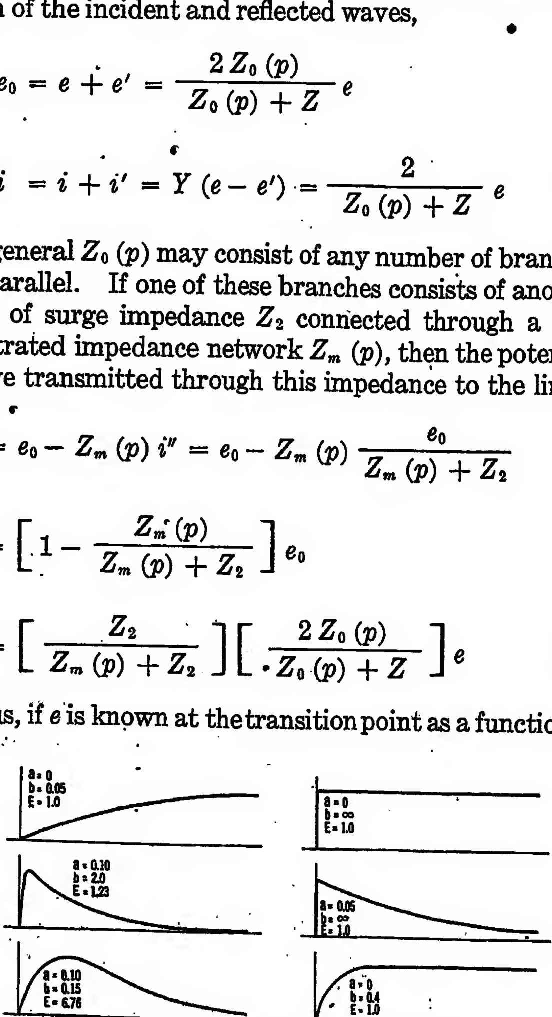

FIG. 12—EMPIRICAL WAVE SHAPES
Given by $e = E\,(\epsilon^{-at} - \epsilon^{-bt})$

time, then e_0, e', and e'' are determined by solving the above differential equations. In particular, if e is a rectangular wave with an infinite tail, it may be taken as Heaviside's *unit function 1* and the solution obtained by means of the expansion formula. The solution for a finite wave of any shape is then found from Duhamel's theorem, equation (24).

The application of these general relationships are illustrated in this paper for the wave of equation (26), with the parameters adjusted to give both a rectangular wave with an infinite tail, and a characteristic lightning wave having a 7-microsecond front and a 13-microsecond tail. The differences in behavior of these two waves is sometimes quite striking, and conclusions based on one of them are not always generally applicable to the other. Only one case will be worked out in

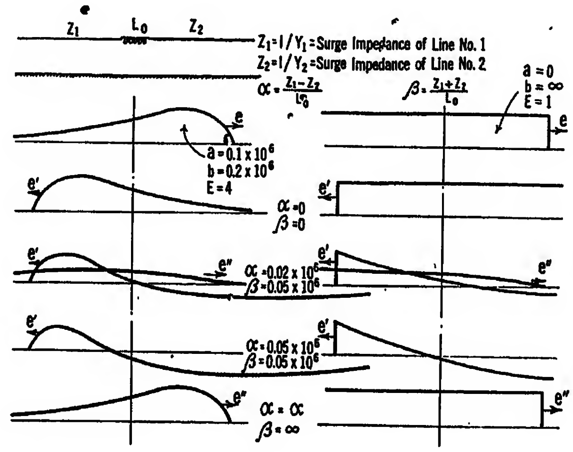

FIG. 22—TWO LINES CONNECTED BY AN INDUCTANCE L_0

$$e = E\,(\epsilon^{-at} - \epsilon^{-bt})$$

$$e' = E\left[\frac{a + \alpha}{a - \beta}\, \epsilon^{-at} - \frac{b + \alpha}{b - \beta}\, \epsilon^{-bt} + \frac{(\alpha + \beta)\,(a - b)}{(a - \beta)\,(b - \beta)}\, \epsilon^{-\beta t} \right]$$

$$e'' = E\left[\frac{\alpha - \beta}{a - \beta}\, \epsilon^{-at} - \frac{\alpha - \beta}{b - \beta}\, \epsilon^{-bt} + \frac{(\alpha - \beta)\,(a - b)}{(a - \beta)\,(b - \beta)}\, \epsilon^{-\beta t} \right]$$

detail in this abridgment. But exactly the same procedure has been followed in deriving all of the results of the complete paper.

1. *Two Lines Connected by an Inductance.* Fig. 22.

$Z_1 = 1/Y_1$ = surge impedance of line No. 1
$Z_2 = 1/Y_2$ = surge impedance of line No. 2
L_0 = connecting inductance

$$Z_m\,(p) = L_0\, p$$
$$Z_0\,(p) = Z_2 + L_0\, p \qquad \text{and let}$$
$$\alpha = (Z_1 - Z_2)/L_0$$
$$\beta = (Z_1 + Z_2)/L_0$$

Then, by equation (30), the reflected potential wave is

$$e' = \frac{Z_0\,(p) - Z_1}{Z_0\,(p) + Z_1}\, e = \frac{(Z_2 + L_0\, p) - Z_1}{(Z_2 + L_0\, p) + Z_1}\, e = \frac{p - \alpha}{p + \beta}\, e$$

If e is a rectangular wave with an infinite tail, the solution by the expansion theorem is

$$e' = \left[\left(1 + \frac{\alpha}{\beta} \right) \epsilon^{-\beta t} - \frac{\alpha}{\beta} \right] \text{if } e = 1$$

and by Equation (24), if $e = E\,(\epsilon^{-at} - \epsilon^{-\beta t})$

$$e' = E\left[\frac{a+\alpha}{a-\beta}\epsilon^{-at} - \frac{b+\alpha}{b-\beta}\epsilon^{-bt} + \frac{(\alpha+\beta)(a-b)}{(a-\beta)(b-\beta)}\epsilon^{-\beta t}\right]$$

From Equation (32)

$$e'' = e_0 - Z_m(p)\, i'' = e_0 - Z_m(p)\, Y_1 (e - e')$$

$$= E\left[\frac{\alpha-\beta}{a-\beta}\epsilon^{-at} - \frac{\alpha-\beta}{b-\beta}\epsilon^{-bt} + \frac{(a-b)(\alpha-\beta)}{(a-\beta)(b-\beta)}\epsilon^{-\beta t}\right]$$

If $\alpha \to \beta$, $e'' \to 0$ and there is no transmitted wave. Taking $Z_1 = Z_2 = 500$ ohms and $L_0 = 0.000833$ henry, there results for the 20-microsecond wave

$\alpha = 0$, $\beta = 30 \times 10^6$, $a = 0.1 \times 10^6$, $b = 0.2 \times 10^6$ and

$$e'' = E\left[\frac{30.0}{29.9}\epsilon^{-at} - \frac{30.0}{29.8}\epsilon^{-bt} + \frac{0.1 \times 30}{29.9 \times 29.8}\epsilon^{-30 \times 10^6 t}\right]$$

$$\simeq E(\epsilon^{-at} - \epsilon^{-bt}) = e$$

Thus such a small series inductance is entirely ineffective except for very short waves. The entire incident wave is transmitted with negligible change of shape.

ACKNOWLEDGMENTS

The author acknowledges with pleasure the many helpful suggestions and encouragement of Mr. F. W. Peek, Jr., under whose direction this investigation was carried out. The curves, numerical computations and planimeter work were done by Mr. W. A. Carman.

Abridgment of

Design Features that Make Large Turbine Generators Possible

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and

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DEVELOPMENT in turbine generators has been so rapid during the past four or five years that any attempt to go into a detailed description of such development would involve too voluminous a work. The purpose of this paper, therefore, is to pick a few facts from a large experience of one manufacturer with the hope that these might be of interest to the profession in general.

62,500-Kv-A. Generator

During the year 1925, the company with which the authors are associated built and installed a 62,500-kv-a. generator, operating at 1800 rev. per min. As this generator constitutes a milestone in the progress of turbine-generator development, it will be in order to give some of the factors which made possible the building of such a machine. The largest previous machines at this speed had a rating of 37,500 kv-a. These machines were ventilated by carrying part of the air to a chamber at the longitudinal center of the machine, from whence it flowed inwardly to the air-gap where it joined the main body of air which had entered the air gap at the two ends, from whence it flowed outward through the remaining sections of punchings. This division of the air was adequate for 30,000-kw. machines. With machines requiring a length necessary for 50,000 or 60,000 kw., it was apparent that to force enough air through them, even though two paths were employed, would require pressures far beyond what would constitute good practise. The natural development, therefore, was to employ a larger number of multiple paths. The employment of a greater number of multiple paths removes the restriction from the air gap and places it in the air ducts themselves. With higher velocities in these air ducts it became apparent that a real gain in efficiency could be made by improving the entrance conditions to these air ducts. The air as it enters the air-gap has a direction parallel with the shaft. As soon as it passes within the restraining walls, formed by the armature and rotor surfaces, it is immediately acted upon by the rotating surface of the rotor and its direction quickly changed from an axial to a tangential flow. By means of specially designed vanes, which were inserted from the back of the punchings directly into the air-gap, a complete study was made of the direction and velocities of the air in the air-gap on actual machines under a wide varying ventilating arrangement.

In order to obtain data as regards the above feature, model sections of armature punchings were made up. These were tested in an air tunnel at pressures and velocities corresponding with those in the actual machine. A vast amount of data was collected on a large number of entrance ducts of many shapes. Some of these data showed that variations as great as 300 per cent were possible in the amount of air put through a given shape of air duct, and in a few cases it was even found that the air actually flowed into the air-gap instead of outward as would be expected.

Figs. 3 and 4 show the variations which exist in different designs of ducts. They represent the maximum and minimum flow under this study.

Armed with these data, the ventilating passages of

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the 62,500 kv-a. were laid out and it is gratifying to report that subsequent tests on the machine verified the earlier experimental results.

The net result of all this information when applied in the design of the 62,500-kv-a. generator was that this generator employing external blowers required practically the same amount of power to ventilate it as the

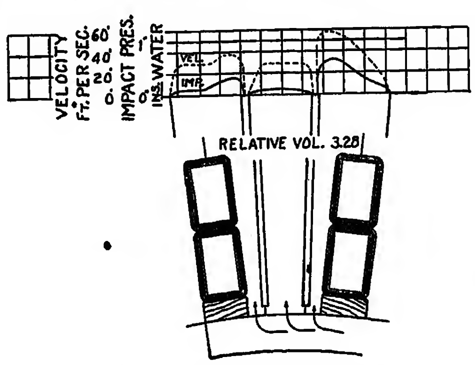

Fig. 3—Air-Flow Curves

Minimum flow obtained—the best shaped retaining wedge; heavy lines—impact; dotted lines—velocity in the three passage ways between slots

30,000-kv-a. previously built. When it is considered that 40 per cent of the loss on a turbine generator was formerly chargeable to windage, it will be seen that this saving in loss constituted a real step forward in the matter of efficiency. The outstanding facts which these experiments indicated, and which subsequent tests on the machine substantiated, was that as far as ventilation was concerned machines of any length could be built and if properly designed they could be as well ventilated as the shorter machines. This conclusion was of the greatest importance as it removed one of the factors which up to this time had more than any other impeded the progress in the size of generating units.

Temperatures and Their Relation to the Size of Units

A few years ago it was thought by some designers, as well as users, that low temperatures were incompatible with large machines. The authors have never shared this view, and after a long experience are more strongly of the opinion that the larger the machine the more conservative the temperature should be.

Some of the largest single-shaft turbine generators built to date have temperature rises, by embedded detectors in the stator windings, of 45 deg. to 50 deg. cent. instead of 60 deg., and of 60 deg. to 70 deg. cent. in the rotor windings instead of 85 deg. cent. as permitted in the contracts.

Most of the armature failures with which the authors are familiar, and which have occurred in recent years, have been the result of mechanical rather than electrical causes. A majority of such cases occurred before the general adoption of the closed ventilating systems of the present day, and were largely brought about by the stoppage of the ventilating passages by foregin substances. This in many cases caused the generation of gases in windings due to the temperatures getting beyond the boiling point of the constituents of the binding varnishes. These gases usually forced themselves along the length of the coil until the restraining influence of the slot walls allowed their escape. Once free of this restraint, they ruptured the insulation wall causing a failure. Still other failures were caused principally in the rotors by purely mechanical movements between the copper and iron, which movements cause an abrasion of the insulation to the point of failure. Either of these effects is greatly multipled when we come to core lengths such as are necessary in machines of 100,000 or 160,000 kw.

It has seemed best, therefore, to feel our way along in the matter of proper temperature rises for the extremely large turbo generators, at the same time putting forth every effort to minimize the serious consequences of expansions and contractions by introducing certain constructions in the windings themselves that will permit of expansions that will not be wholly longitudinal and at the same time continue the improvements that have already been made in the quality of the varnishes or other cementing materials employed in the hope of eventually obtaining insulations for

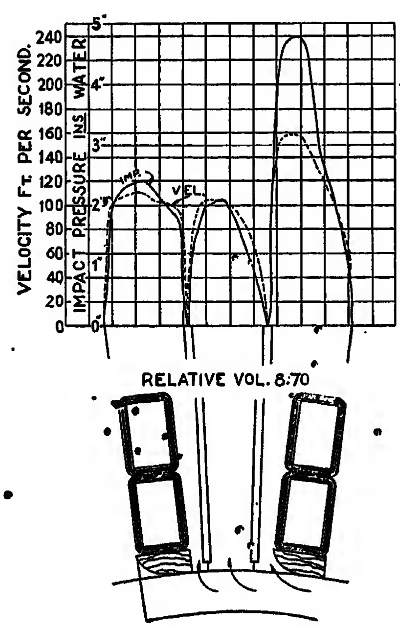

Fig. 4—Air-Flow Curves

Maximum flow obtained—no retaining wedge across air duct; heavy lines—impact; dotted lines—velocity in the three passage ways between slots

high voltages that will be able to withstand much higher temperatures.

It can readily be seen that the quantity of insulating material is a factor in the temperature rises and that insulations should not be any thicker than what is required to give the dielectric strength needed for the highest potentials generated in service.

Losses and Their Relation to Output

It is a much mooted question as to the relation that should exist in any given instance between the armature and the field magnetizations. High armature reaction

becomes overpowering unless the designer by increasing the air-gap maintains a ratio within such limits as he thinks will prove satisfactory in operation. The relation of field ampere-turns at no-load, normal voltage, to field ampere-turns on short circuit with normal current is known as the short-circuit ratio. Hence, a low short-circuit ratio tends to a high rating for the speed under consideration and the physical dimensions of the machine.

Machines of greater rating are possible when magnetic materials of the best quality are employed. Any reduction in the fixed losses in the generator is of a two-fold benefit, for less air is required to provide the proper ventilation with lower power loss chargeable to the ventilation. For each kilowatt saved in these losses, approximately 0.25 kw. less power is required to ventilate such a machine.

Higher armature reactions or lower short-circuit ratios result in an increase in the so-called load losses; at the same time they reduce other losses and result in cheaper machines. A proper balance then must be maintained between these factors so as to obtain machines of great reliability and long life.

With enormous amounts of power built into a single unit the desirability of building machines of great reliability cannot be overemphasized.

In a previous paper the authors made reference to investigations which were carried out in regard to losses existing in machines of this type with particular reference to those losses in the so-called inactive magnetic materials at the heads of machines. As a result of these and subsequent investigations the practise of using magnetic steels for such parts as the clamping fingers and flanges has been discontinued on all of these large machines, and non-magnetic materials substituted for them. The employment of these non-magnetic steels has resulted in a gratifying reduction in the losses. As a result of these and other improvements the efficiencies of these large units are of the order of 98 per cent instead of the 96.5 to 97 per cent which were the rule a few years ago.

One of the contributing factors in the trend toward larger units is the increased efficiency which such a unit brings. High efficiency, therefore, assumes an importance in these large units far beyond what it did in the units of years ago. The design factors for which the modern designer must strive in the order of their importance should be reliability, efficiency, and cost. If these factors are followed through to a logical conclusion, the size of units for a given output becomes greater than what would obtain if machines were designed to get the greatest output compatible with their temperature guarantees.

Due to their high rotational speed, the frictional loss, commonly called windage loss, becomes a serious factor in the efficiency of this type of unit. The problem of operating this class of apparatus in a medium of low density has claimed the attention of engineers for years. With the advent of the closed system of ventilation and surface coolers for extracting the heat from the cooling medium, the problem of the utilization of a gas lighter than air received a marked impetus. Hydrogen cooling is a perfectly practical thing and its adoption will mark the next big step forward in the increase in efficiency of these large units. By employing H_2 cooling we may expect an increase in efficiency of some 0.6 per cent and some 25 per cent large outputs from the same physical size of units.

High-Voltage Generators

Within the past few years interest has developed both in this country and abroad in generators built for voltages higher than those which had been standard; namely 13,200–14,000 volts. The trend toward higher voltages has been brought about largely by the increase in generator capacities, and in an effort to minimize switching difficulties.

The distribution areas being so widely scattered in this country, most of the power from the large stations to-day is sent out at potentials much higher than it would be possible with our present knowledge to build generators for. No attempt, therefore, has been made to adapt the generator voltage to the transmission potential. In those cases where power is distributed at various potentials, say 33,000, 66,000, and 132,000 volts, it is usually cheaper to use step-up transformers for all three voltages than to wind the generator for 33 kv. and use step-up transformers for the two remaining voltages.

All of these considerations have worked together to confine the building of large generators to the potentials which are most economical in station switching and bus bar equipment.

The introduction of the so-called double winding in large generators has retarded to some extent the trend to higher voltages in these machines. Briefly, this double winding consists in dividing the coils which make up the three phases into two circuits, and arranging them in the correct slot relationship in such a manner that they will be in phase and voltage agreement with high self-induction with respect to each other.

Each winding, therefore, will carry half the output of the machine. If these independent windings are tied to separate busses, the switching problem is greatly minimized, as the current to be handled is just half of what would be the case in an ordinary generator; or it would be the same as if the generator were wound for 27,600 instead of 13,800 volts.

Rotor

No description of generator development would be complete without some reference to the rotor as no part of these large generators has come in for such careful analysis and painstaking study as the revolving element. It is this element which must withstand all of the centrifugal strains, bending strains, and temperature strains due to heating and cooling and still maintain its alinement and balance so as to provide smooth operation.

There are three distinct types of rotors built by the

leading manufacturers of to-day. The first is the solid rotor type in which the rotor is made up of one or more forgings. The second is the plate rotor type in which a series of plates or disks is bolted together to form the rotor body structure. The third is the through-shaft dovetail punching type, in which the shaft is a solid forging which has been slotted and dovetailed to receive the punchings which carry the rotor coils.

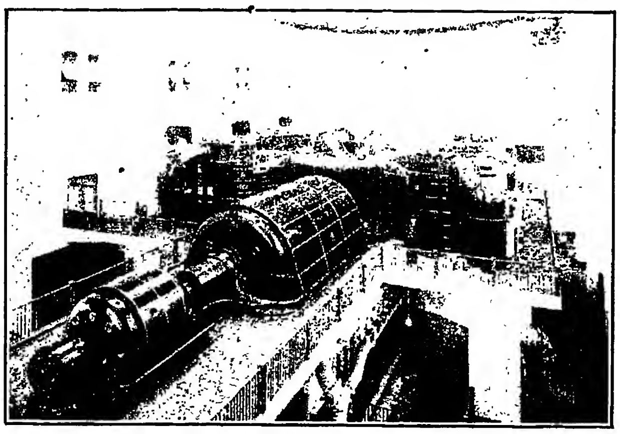

Fig. 6—100,000-Kv-a., 1500-Rev. per Min., 16,500-Volt, 50-Cycle Generator

With 4000-kw auxiliary generator and 94,000-kw. tandem compound turbine. Long Beach Station of So. California Edison Co.

Each of these types has its advocates, and each type has some inherent advantages which the others do not possess. From time to time articles appear in the technical press of the world in which some author attempts to point out the superiority of one type over another. Such articles are distinctly all right as they tend to stimulate thought which leads to progress. The authors have no intention of joining in such a controversy. Their first-hand knowledge would allow them to speak with some authority on only two of the three types.

Suffice it to say that the manufacturing company with which the authors are associated has brought its steel forged type of rotor to its present state of perfection only after the most careful and painstaking research and that over one thousand of these rotors have been built and put into service and not one of them has failed due to imperfections in the rotor forging. This is an enviable record and is a most convincing argument that this type of rotor is thoroughly reliable if properly built.

In the design of the 62,500-kv-a. generator, described earlier in this article, the rotor diameter was the same as those of the 30,000-kv-a. previously built. The centrifugal stresses, therefore, were no greater than had been previously encountered. With further increases in capacity of the units the diameters have been increased. Many of the stresses, however, on these rotors of greater diameter have not increased due to the fact that the copper space has not been increased in proportion to the increased diameter. The body stresses have increased somewhat but, to offset this, alloy steels are being employed which give a higher factor of safety than many of the smaller units enjoyed.

100,000-Kv-a., 16,500-Volt, 1500-Rev. per Min. Generator

Fig. 6 shows the 100,000-kv-a., 16,500-volt, 1500-rev. per min. generator installed in the Long Beach Station of the Southern California Edison Co. This is the largest single turbine generator in operation in America. Its design brought up a number of problems largely mechanical, which are typical of the trend in modern design. When the order for this unit was placed, it was contemplated that the machine would be assembled at destination. The difficulty of transporting all of the component parts of a machine of this size 3000 miles across the country, and assembling them under conditions which are anything but ideal, made it seem desirable to design the machine so that it could be shipped completely assembled and wound. A design was finally worked out whereby both the weight and dimensional requirements for shipment could be met. The frame was divided into two parts, an inner member or cage (see Fig. 7) and an outer structure (see Fig. 8). The inner member consists of annular plates held on the outside by narrow steel slats, and on the inside by the core dovetail ribs which were let into the plate. This structure is intended largely as an assembling jig for the punchings. After the punchings were assembled and clamped the ribs and outside slats were welded in place. The whole structure thus became a rigid member which could be handled.

The outer structure consists of a number of foot plates spaced so as to coincide with the circular plates of the inner structure to which they are securely bolted when assembled on the base. These foot plates are welded to side plates which form an enclosure and add stiffness horizontally. Over this structure when assembled is placed a steel cover. This cover plate also carries radial supporting plates which form the various air chambers.

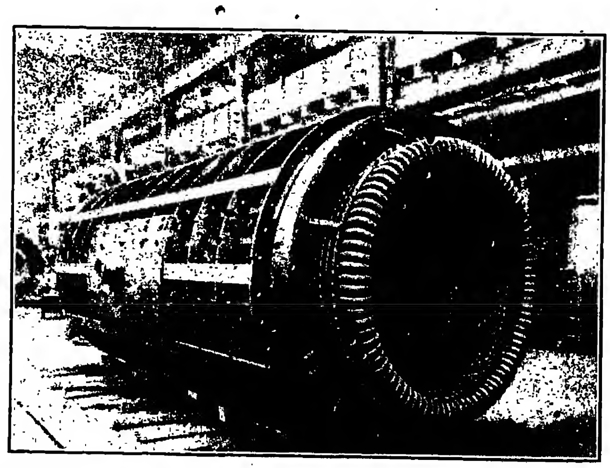

Fig. 7—100,000-Kv-a., 1500-Rev. per Min., 16,500-Volt, 50-Cycle Generator

View of inside stator structure complete with winding and supports. Turbine end

160,000-Kw., 1500-Rev. per Min., 25-Cycle Generator

The use of 25-cycle power has practically given way

to 60 cycles in this country except in certain districts, notably around Niagara Falls and the metropolitan area of New York. While these latter places are considering the problem of changing over to 60 cycles, they still require large blocks of 25-cycle power.

Fig. 9 shows the frame with the ventilating housing and cooling casing for the 160,000-kw., 25-cycle, 1500-rev. per min. generator for the New York Edison Company and installed in their 14th Street station. The building of a generator of this enormous capacity involved a number of new problems. The frame (see Fig. 10) is made entirely of steel plate welded and represents the most approved practise in this construction.

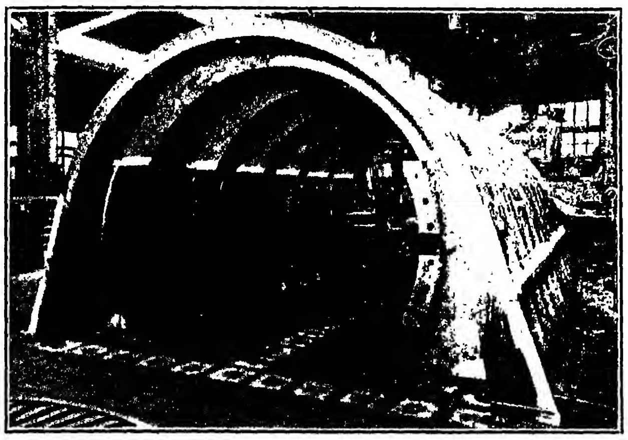

Fig. 8—100,000-Kv-A., 1500-Rev. per Min., 16,500-Volt, 50-Cycle Generator

View of outer stator frame shipped separately and bolted to inside structure at destination

The non-magnetic steel clamping flanges at the two ends of the stator and the cast iron end shields are the only castings in the generator proper. The employment of steel plate and the application of the art of welding has resulted in marked reduction in weight and at the same time resulted in a much stronger structure than was possible with fabricated cast iron structure formerly built. As an example of this weight reduction. a recent design of frame on a 75,000-kv-a. generator showed practically the same weight as the frame of a 37,500-kv-a. generator of an earlier design in which castings were employed. Owing to the physical dimensions of the 160,000-kw. generator and enormous weight, the stator of this unit was built at destination. Specially designed trunnions were necessary in order that the frame, after it had received its load of half a million pounds of laminations, could be turned from a vertical to a horizontal position on its base. See Fig. 10.

The winding of this generator is of the transposed bar type with two bars assembled in each slot. This is the first machine to make use of the two circuit or so-called double winding. Each winding is connected delta and, to eliminate the objectionable harmonic currents in the delta, the pitch of the coils was made 66⅔ per cent. Each winding will be connected to a separate bus section and these busses will have no tie between them other than the generator windings. In case of a short circuit on one bus the generator windings act as a limiting reactor in reducing the flow of current along the bus.

There is not contemplated at the present time, as far as the authors know, a turbo generator larger in capacity than this unity power factor 160,000 kw. It may not be generally known to engineers other than designers that it is more difficult to design a 25-cycle machine of great capacity than it is to design a 50-cycle at the same speed, namely 1500 rev. per min. The amount of magnetic material is much greater for the lower periodicity and the extensions of the end windings of both stator and rotor beyond the magnetic cores are much greater. Hence, the authors have confidence that by the introduction of certain features discussed in this paper, such as hydrogen cooling, a 50-cycle generator conservative in its temperatures and other important characteristics could be designed and built at the present time for a rating of 200,000 kw. at 90 per cent power factor, or 222,222 kv-a.

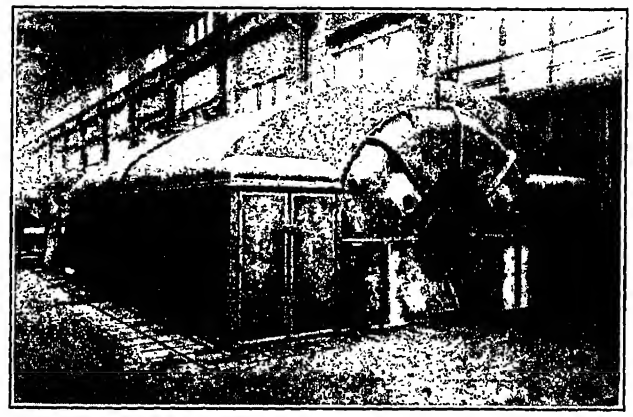

Fig. 9—160,000-Kw., 1500-Rev. per Min., 11,400-Volt, 25-Cycle Generator

Ventilation housing containing the coolers

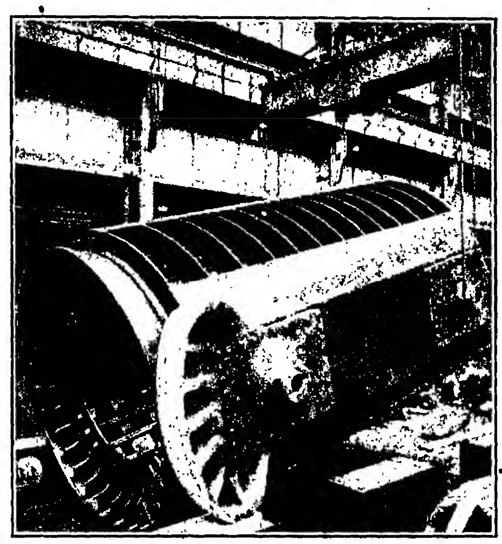

Fig. 10—160,000-Kw., 1500-Rev. per Min., 11,400-Volt, 25-Cycle Generator

Showing stator frame and the special trunnion for changing after stacking core from vertical to horizontal position

Abridgment of

Short-Circuit Torque in Synchronous Machines without Damper Windings

BY G. W. PENNEY*
Associate, A. I. E. E.

Synopsis.—The torque produced by a short circuit is first discussed in a general way, showing that it is pulsating in nature. The average value of torque is determined by the resistance and other energy, losses but the instantaneous value rises far above the average value. The major part of this pulsating torque is produced by the change in stored magnetic energy. General equations are derived for the torque in a machine having negligible resistance and constant self-inductance of each winding and which is referred to as an "Ideal Machine."

These equations are useful in comparing single-phase and various polyphase short circuits and for determining general tendencies. However, the numerical value of the torque is usually of greatest interest in salient-pole machines and here the self-inductance of the armature winding is not constant. The calculation of torque from the actual inductance of the windings of a salient-pole machine is a very complicated problem. A relatively simple step-by-step calculation, called the "semi-graphical method," is developed for calculating the torque from the actual currents as given by an oscillogram. The effect of resistance can be included in this calculation. The method holds for any variation in self inductance with rotor position provided that saturation is not a large factor in determining the change in stored magnetic energy, which seems to be true in cases thus far investigated.

Short-circuit torque can be measured by an instrument described in a previous paper.[4] The torque as measured is compared with the torque as calculated by various methods. This shows that calculations based on constant self-inductance of each winding may be seriously in error, particularly if equations derived on this basis are applied to the actual currents of salient-pole machines. The "semi-graphical" method agrees reasonably well with measured values for cases tested so far.

* * * * *

THE failures occasionally produced by short circuits show that tremendous forces must result from short circuits and other transient phenomena. For example, one of the early large vertical waterwheel generators of low reactance at Niagara Falls sheared off the holding down bolts and the stator turned through a considerable angle on its foundation. In another case, a frequency-changer set stretched the holding down bolts and cracked the frame-supporting feet when the set was connected to the line out of phase. It is only necessary to stand beside a low-reactance machine when it is short-circuited to realize that very severe forces are acting on the machine. Synchronizing out of phase may produce forces which are even more severe. This paper is confined to the subject of short-circuit torque although the methods proposed can be used, with some modifications, for determining the torque during synchronizing and other transient conditions.

One difficulty in understanding the torque produced by a short circuit is the fact that the assumptions generally used for calculating the torque during normal operations do not represent the conditions during a short circuit. In calculating the torque during normal operation, it is usually assumed that the stored energy is constant so that the mechanical torque of a generator is equal to the electrical output plus the losses. If a generator is short-circuited at its terminals, its electrical output is zero and the energy losses within the machine account for only part of the torque which is known to be produced. An investigation of the stored magnetic energy of a machine during short circuit shows that this energy fluctuates very rapidly and that there is a corresponding fluctuation of the kinetic energy of

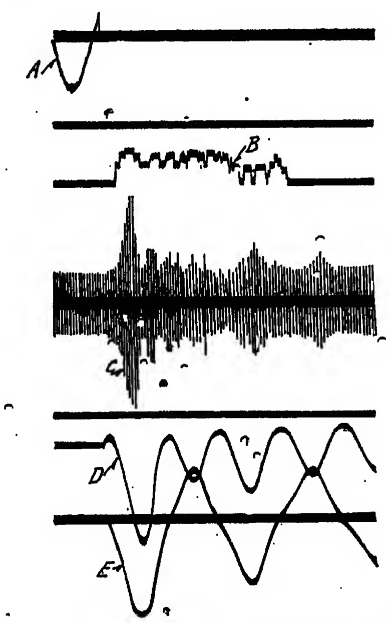

Fig. 1—Tracing of an Oscillogram for a Single-Phase Short Circuit

A—Terminal voltage
B—Current through a group of contacts—the record of the contact and flywheel accelerometer measuring torque
C—800-cycle current—the magnetic record of acceleration or torque
D—Field current
E—Current in the short-circuited phase

the rotating mass. The transfer of kinetic energy to magnetic energy, and vice versa, must be accompanied by a torque which alternates between positive and negative values.

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4. For numbered references see bibliography in complete paper.

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The law of conservation of energy is used to determine the torque during a short circuit. Electrical power cannot flow into or from a short-circuited machine. However, mechanical power coming from either the kinetic energy of the rotor or transmitted from a mechanically connected machine may be transformed into electrical power by the interaction of the currents and fluxes. Therefore, applying the law of conservation of energy, any increase in the sum of the stored magnetic energy, plus the integral of the energy dissipated, must be accompanied by a transfer of mechanical energy to magnetic energy. Conversely, any decrease in the sum of the stored magnetic energy, plus the integral of the energy dissipated, must be accompanied by a transfer of magnetic to mechanical energy. Or expressed mathematically:

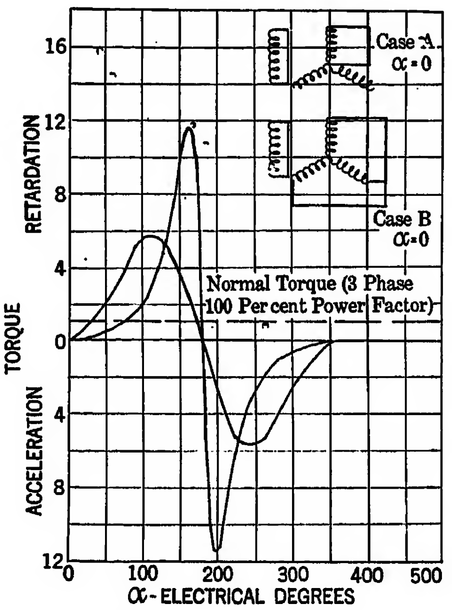

FIG. 3—TORQUE DEVELOPED BY SHORT-CIRCUIT OF AN "IDEAL MACHINE"

A. Single-phase short circuit, terminal to neutral
B. Three-phase short circuit, terminal to terminal

Assumptions:
1. Short circuit occurs when generated voltage on phase is zero
2. Star-connected winding

$K = 0.85 = \frac{M_{AF}}{L_f}$

4. Peak non-symmetrical terminal-to-terminal short-circuit current equals 12 times rated r. m. s. value of current per phase

$$U + \int R\, i^2\, d\,t = U_0 + \int T\, w\, d\,t$$

Differentiating,

$$\frac{d\,U}{d\,t} + R\, i^2 = T\, w \tag{2}$$

If resistance is negligible, this reduces to,

$$\frac{d\,U}{d\,t} = T\, w \tag{3}$$

where

t = time
R = resistance
U = stored magnetic energy
T = torque
W = angular velocity
i = current

From this it is evident that if the stored magnetic energy can be determined for each increment of time, the corresponding mechanical torque can be calculated. The torque discussed here is the resultant tangential reaction of the windings. The torque acting on individual parts will depend on the mechanical arrangement. In the case of the synchronous condenser, the shaft does not transmit any torque. In this instance the torque produced by the winding merely results in a change in speed of the rotor. The other extreme exists in a rigid rotor connected to an infinitely large flywheel by a perfectly rigid shaft. In this case the speed of the rotor must be constant and therefore all of the torque produced must be transmitted by the shaft. Actual cases will usually be somewhere between these two extremes. The torque acting on individual parts of the machine is outside the scope of this discussion. In this discussion the term "short-circuit torque" will be taken to mean the resultant reaction of the windings. During open-circuit operation of a

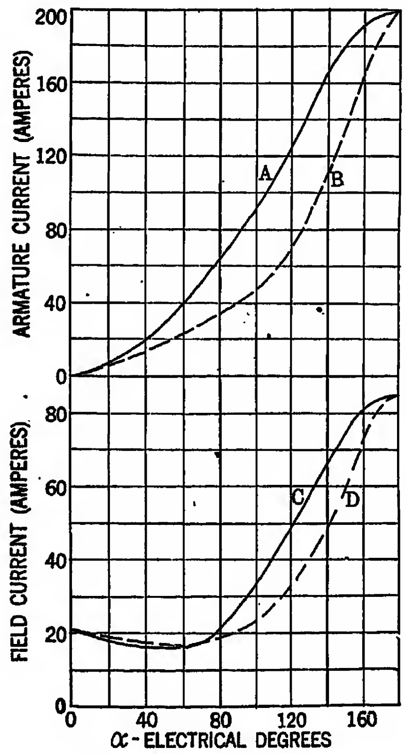

FIG. 4—COMPARISON OF ACTUAL AND THEORETICAL CURRENT WAVE SHAPE FOR SINGLE-PHASE UNSYMMETRICAL SHORT CIRCUIT

A and C,—Armature and field current, respectively, from oscillogram
B and D,—Armature and field current, respectively, from Equations (40) and (41) in paper by R. F. Franklin (B-3) with the value of K chosen to give same maximum values as A and C

machine there is a certain field current and flux giving a substantially constant stored magnetic energy. However, at the instant of short circuit, a large armature current is produced and the field current rises to several times its normal value, which results in a corresponding increase in the stored magnetic energy.

The complete paper gives a mathematical treatment for a machine to which the following assumptions would apply;

1. The self-inductance of each winding is constant.
2. The mutual inductance between field and armature circuits varies as the cosine of the angle between the two windings.
3. Resistance is negligible. An alternator to which these assumptions apply is called an "ideal machine."

Using the currents and fluxes of the machine, the stored energy is calculated and the result differentiated to get the time rate of change of stored energy which, from Equation (3), is equal to the torque. This gives the following equation for a single-phase short circuit.

$$w\,T = \frac{d\,U}{d\,t} = i_a e_a \, \frac{i_f}{I_f} \qquad (11)$$

And for a three-phase short circuit,

$$w\,T = \frac{d\,U}{d\,t} = [i_a\,e_a + i_b\,e_b + i_c\,e_c]\,\frac{i_f}{I_f} \qquad (14)$$

Where U = instantaneous short-circuit current, subscripts a, b, c, and f, referring to the three phases and field, respectively; e = voltage that would have been generated at the same rotor position under open-circuit conditions, subscripts a, b, and c referring to the respective phases. I_f = field current under open-circuit conditions.

Semi-Graphical Determination of Torque

The equations just given are useful for comparing a single-phase short circuit with various polyphase short circuits and determining general tendencies. A turbo alternator approximates the constant self inductance of each phase on which the equations were based. However, the salient-pole machine has an inherently less rugged construction than the turbo alternator, so that the determination of short-circuit torque is of greater importance in the salient pole machine where the variation in self-inductance must be considered. If the variation in the inductance of the windings is accurately known and the currents calculated, Equation (12) may be used to calculate the torque. In this case the calculations become complicated so that the method is cumbersome.

The semi-graphical method has been developed for calculating the torque from an oscillogram of currents, and eliminates the necessity of determining the inductance of the separate circuits. The method is based on the assumption that the stored energy of n circuits is equal to $\sum_{1}^{n} \frac{N_u\,\phi_u\,i_u}{2}$ as given by Equation (35). This equation holds for any self-inductance and mutual inductance between the circuits involved,

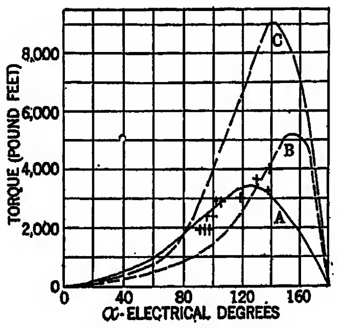

Fig. 5—Comparison of Methods of Calculating Torque

A. Torque calculated from the "Semi-Graphical" method for current values *A* and *C* in Fig. 4. Points indicated by "+" show the torque as recorded by the contact accelerometer

B. Torque calculated for current values *B* and *D* in Fig. 4. Note that semi-graphical method and Equation (11) give the same results in this case since the current is based on constant self-inductance of each circuit

C. Result of applying Equation (11), which was based on constant self-inductance. to the actual current (Curves *A* and *C* in Fig. 4) from a machine having variable self-inductance

provided saturation is negligible. The flux can be determined from the initial conditions and, assuming that the resistance is negligible, will remain constant during the first instant of short circuit. Then, by taking the values of current from an oscillogram, the energy of the magnetic field can be calculated without determining the inductance of the various circuits involved. The energy can be calculated for successive positions of the rotor and by taking the difference in successive values, the change of energy and the resulting torque can be calculated.

Since the result depends upon differences between successive values, the values of current must be ac-

TALE I

CALCULATION OF TORQUE NEGLECTING RESISTANCE

α degrees	i_f amperes	$\frac{N_f\,i_f\,\phi_f}{2\,10^8}$	i_a amperes	$\frac{N_a\,i_a\,\phi_a}{2\,10^8}$	(Joules) energy U	ΔU (joules)	$\frac{\Delta U}{\Delta \alpha}\,.\,2.21$ = torque (lb.-ft.)
20	27	506	0		506		
30	25.5	478	7	42.4	520	14	177
40	23.5	440	23	140	580	60	760
50	23	431	40	242	653	73	965
60	23.5	440	57	345	785	72	910
70	25.5	478	75	454	932	147	1860
80	29.5	552	94.5	572	1124	192	2430
90	36	675	118	685	1360	246	3120

curately determined and the increments of time used must be large enough so that the change in current can be measured accurately. This calculation is illustrated in Appendix IV of the complete paper. Successive values for one case are tabulated in Table I, and the result plotted for Curve C of Fig. 6.

Equation (35), which is used to determine the stored energy in the "semi-graphical" method, is based on the

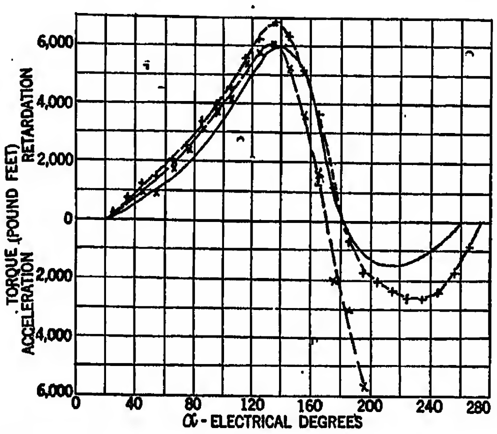

FIG. 6—TORQUE PRODUCED BY A SINGLE-PHASE SHORT CIRCUIT

B + — — — Calculated from the recorded currents considering the effect of resistance

C × ——— ———Calculated neglecting the effect of resistance

A——— Torque recorded by the magnetic accelerometer

⊙ Torque recorded by flywheel and contact accelerometer

assumption of no saturation. This question is discussed in the paper showing that saturation has a large effect on the initial stored energy, but that in determining the increase in stored energy in usual machines, saturation has only a very small effect, since the flux through the main iron paths is substantially constant, most of the increase in stored energy coming from the flux traversing leakage paths through non-magnetic material. For this reason, in the calculation of torque, saturation can be neglected with only a small error.

The Effect of Resistance. Thus far, the effect of resistance has been neglected. Assuming that the currents are taken from an oscillogram, the effect of resistance on the torque calculation is two-fold. First, the resultant flux interlinkage of each circuit is constant only when the resistance of the circuit is negligible. Actually, to overcome the resistance drop in a short-circuited winding, the electromotive force must be supplied by the change in flux interlinkages of that circuit $\left(i.e., R\,i = e = N\,\dfrac{d\,\phi}{dt}\right)$. Secondly, the power represented by the resistance loss is usually not negligible because of the large values of current involved.

These two effects of resistance can be incorporated in the step by step calculation of torque. The decrease in flux interlinkages can be calculated for each increment of time and this value used to obtain the actual flux interlinkages and corresponding stored energy. The torque corresponding to the resistance loss can be calculated and added to the torque resulting from the change in stored energy. This calculation, considering resistance, is illustrated in Table II of Appendix IV of the complete paper and the torque obtained plotted as Curve B of Fig. 6.

These calculations are for the short-circuit recorded on the oscillogram of Fig. 1. On this oscillogram the terminal voltage, field current, and armature current are shown. Also the torque is recorded on the oscillogram by the accelerometer described in a paper at the Pittsfield Regional Meeting in 1927.[4]

Discussion of Results

The torque produced by a single-phase short circuit varies greatly with the position of the rotor at the instant when the short circuit occurs. This discussion has been devoted almost entirely to the subject of short circuits occurring at the instant when the terminal voltage is zero, which gives the greatest torque. This was done because the designer is interested in the worst condition that can happen. In the tests made, the instant of short circuit was controlled to give this worst condition. However, in operation very few of the short circuits will occur at this particular point. In most cases the torque will be very small compared to the worst condition.

In the first part of this paper equations were derived for an "ideal machine,"—that is, a machine to which the assumptions frequently used in discussing short-circuit currents would apply. The equations for currents derived on this basis are quite generally applied to

TABLE XI

CALCULATION OF TORQUE CONSIDERING THE EFFECT OF RESISTANCE

Note: This example exaggerates the effect of resistance, since a 60-cycle machine was short-circuited while running at 25-cycle frequency and since both field and armature terminals were short-circuited

α degrees	$\dfrac{R_f\,i_f\,\Delta t = N_f\,\Delta\,\phi_f}{10^8}$	$\dfrac{N_f\;\phi_f}{10^8}$	$\dfrac{N_f\,\phi_f\,i_f}{2.10^8}$	$\dfrac{R_a\,i_a\,\Delta t = N_a\,\Delta\,\phi_a}{10^8}$	$\dfrac{N_a\phi_a}{10^8}$	$\dfrac{N_a\,\phi_a\,i_a}{2.10^8}$	U (joules)	$\dfrac{\Delta U}{\Delta_a}$. 2.21 torque (lb-ft.)	Torque from resist. losses	Total torque lb-ft.
20	0	37.5					502			
30	0.13	37.37	475	0.02	12.08	42	517	190	45	235
40	0.13	37.24	435	0.06	12.02	138	573	710	52	762
50	0.12	32.12	425	0.10	11.92	240	665	1140	85	1225
60	0.12	37.00	432	0.14	11.88	336	768	1310	138	1448
70	0.12	36.88	468	0.19	11.69	435	903	1840	225	2065
80	0.14	36.74	540	0.24	11.45	540	1080	2240	345	2585
90	0.21	36.53	655	0.31	11.14	625	1280	2530	506	3036

salient-pole machines with reasonably satisfactory results. However, as has been mentioned, it must not be assumed that the equations for torque derived by using these same approximations can be as generally applied. Figs. 4 and 5 are intended to emphasize this fact. In Fig. 4 the actual wave shape of the currents for a certain machine are compared with the wave-shapes as given by the equations derived by Franklin,* assuming constants which would give the same peak value of current in both cases. This agreement is satisfactory for most purposes. However, since the torque depends upon the rate of change of current, the value will be very different for the two cases. In curves A and B of Fig. 5 this is shown. The area under the two curves is the same since the maximum stored energy is the same, but the rate of change of energy is very different giving a corresponding difference in the value of peak torque.

It might be assumed that Equation (**11**), which gives the torque in terms of the currents during the short circuit and the voltage before the short circuit, could be applied to actual measured currents in cases where the self inductance of the separate circuits is not constant. However, the torque corresponding to a given current depends on the rate of change of inductance. For this reason this equation for torque is true only when the currents vary as in the "ideal machine." For instance, if these equations are used with the values of current given by Curves A and C of Fig. 4, the torque obtained would be that for the given values of current, but assuming that that current was varying at a rate given by the theoretical equations. The error corresponding to this assumption is shown by Curve C of Fig. 5, which gives a maximum torque almost three times the actual value, whereas the torque calculated by the semi-graphical method agrees very closely with the measured torque.

Mr. Theo. Williamson conducted most of the tests referred to and his work is hereby acknowledged, as are the suggestions of Messrs. Fechheimer and Soderberg, under whose supervision the work was done.

*Equations (**40**) and (**41**), *Short Circuits of Synchronous Machines*, (Reference 3.)

Abridgment of

An A-C. Low-Voltage Network
without Network Protectors

BY LESTER R. GAMBLE[1] and EARL BAUGHN[2]
Member, A. I. E. E. Associate, A. I. E. E.

Synopsis.—*The object of this paper is to present a description of the underground network system in Spokane, Washington, and to describe the operating experience and problems resulting from the installation of ring primary feeders and a four-wire 120/208-volt secondary network supplying universal service.*

Reasons for the choice of the system described are presented with particular reference to the use of a fuse in the secondary circuits instead of the "Network Protector" device.

The general design of the primary feeders, secondary network, pilot-wire relays and fuse protection, and transformer vaults is discussed.

Descriptions of all apparatus and equipment are given.

A report is included covering tests made under fault conditions. The tests, which simulated actual operating conditions, indicate that the system will operate as designed.

The paper concludes with a statement that no difficulties have been encountered on the system and that its operation to date has been perfect.

Introduction

In 1923 a general survey was made of the three-wire Edison d-c. system serving the downtown district in Spokane. The survey indicated that the demands for electric service were placing many limitations on the d-c. system.

However, the d-c. system was very satisfactory considering the continuity of service. There had been few cases of trouble, with only one complete interruption since the mains and feeders were placed underground in 1910. Because of this excellent record, there was considerable opposition to any suggestion of substituting an a-c. system in the downtown area. Investigations showed many advantages of a-c. service over d-c. service, both to the consumer and to the company, which resulted in a policy to limit the further growth of the d-c. system by substituting an a-c. low-voltage network.

Fig. 1B shows the arrangement of circuits and transformer vaults, the plan being to limit the growth of the d-c. system by surrounding it with an a-c. network system, making it unnecessary to expand the d-c. service into new districts.

Type of A-C. System Selected

In comparing the d-c. system with an a-c. system

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having equal reliability, it was found that the latter had certain outstanding advantages; namely, high efficiency and low cost per kilowatt delivered.

The system adopted consists of three-phase, 4000-volt primary ring feeders, sectionalized by oil circuit breakers operated by means of a pilot-wire relay circuit, and a three-phase, four-wire, 120/208-volt secondary network supplying a combined light and power service.

The ring type feeder seemed preferable to the radial, first, because it made it possible to give a two-way feed to isolated loads which could not be connected to the secondary network and which, due to their importance, would require a very expensive service from two primary feeders with special throw-over equipment, and second, because an analysis of the annual costs of the two types of feeder systems gave, for the particular area to be supplied, a lower cost for the ring feeder.

The a-c. secondary network was adopted because it was felt that the high standard of service which had been provided by the d-c. network should not be lowered by the substitution of a radial secondary.

The plan of combined light and power service was selected because of the savings attendant on such a system.

The installation of ring primary feeders required the use of protective and sectionalizing devices differing radically from those used on radial feeder systems. Such systems used a device known as the "Network Protector" for sectionalizing faults. With ring feeders, however, the network protector is not necessary, especially where fuses can be used effectively to accomplish the same result.

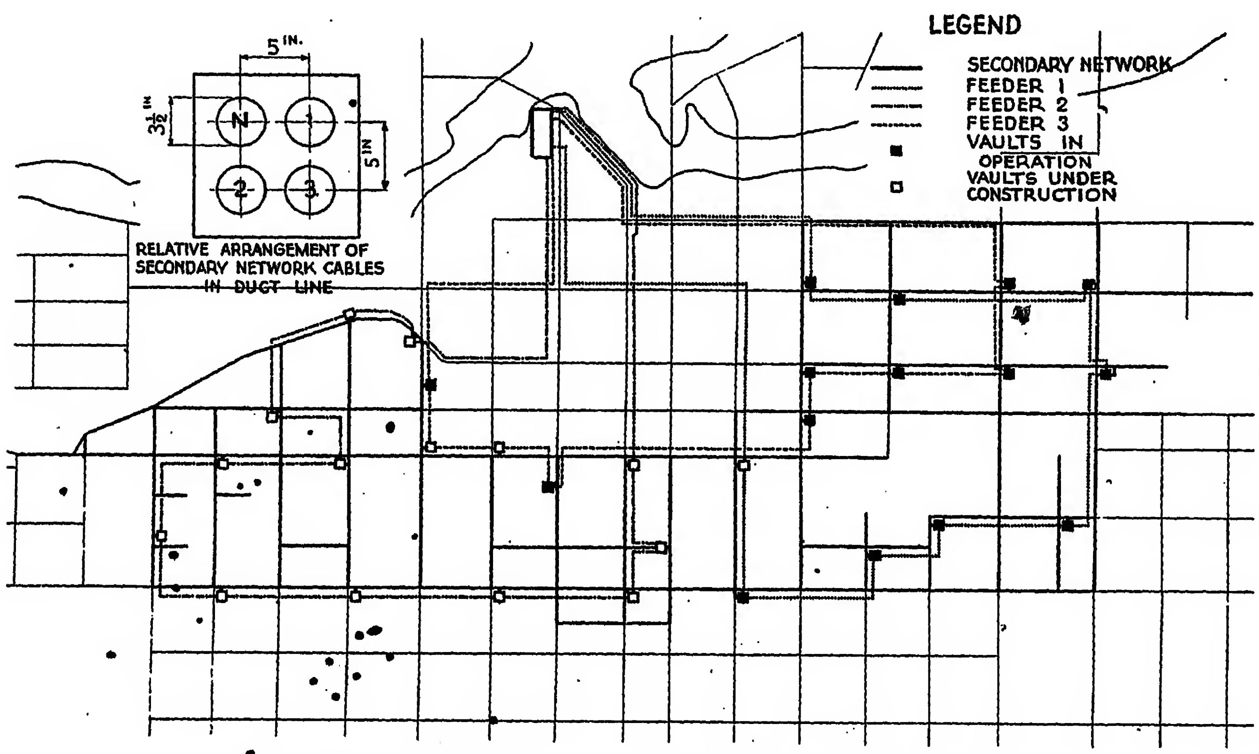

Fig. 1B Secondary Network and Primary Feeder Arrangement

Description of System

The system layout from substation to secondary network is shown schematically in Fig. 2.

Primary Feeders. The primary feeders consist of three-conductor, 250,000-cir. mil, 4000-volt, paper-insulated, lead-covered cables. Each feeder is rated at 300 amperes.

The feeders are interlaced and the transformer vaults connected so that with the loss of more than one section of a ring feeder or the loss of the entire feeder, the service on the secondary network is maintained.

Oil Circuit Breakers. The oil circuit breakers installed in the transformer vaults for sectionalizing purposes in case of faults in the primary feeder are rated at 15,000 volts, 400 amperes, and 20,000 amperes interrupting capacity at 4000 volts. The maximum short-circuit current in case of a fault on a primary feeder is about 10,000 amperes. Fig. 3 shows one type of oil circuit breaker used.

Each oil circuit breaker contains six, bushing type current transformers, with 60 to 1 ratio and two five-ampere trip coils.

Primary Junction Boxes. Two types are in use; one a three-phase, four-way; the other a single-phase, four-way. In either type, two of the four-ways are used for the incoming and outgoing feeder, one for the transformer tap leads and the fourth, a spare.

The single-phase type, which is oil-filled, is shown in Fig. 3.

Transformers. These are standard type, single-phase, 2400-120/240-volt, with two five per cent taps of 18 and 19 to 1 ratio and reactance of 4.3 per cent. The

sizes used are 50-, 100- and 150-kv-a. A 6000-to-5 ratio current transformer on one of the secondary leads is located inside each transformer tank and used as a part of the pilot wire relay scheme described later. The transformers are Y-Y connected. The primary and secondary neutral is connected to the neutral of the secondary network, which, in turn, is connected to the d-c. Edison neutral.

Secondary Junction Boxes and Fuses. The trans-

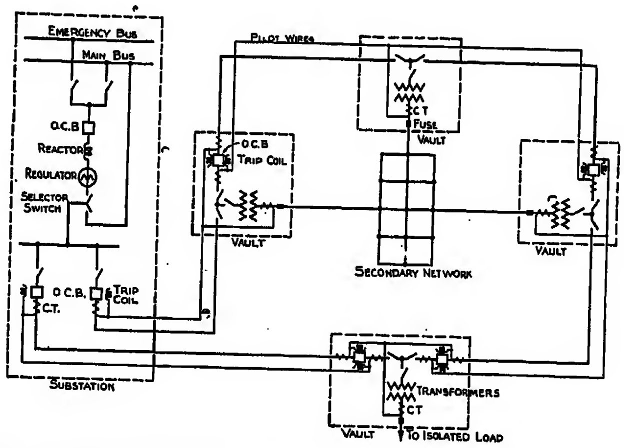

FIG. 2—ONE-LINE DIAGRAM OF ONE PRIMARY RING FEEDER

former secondaries are fused to the mains by open, link type copper fuses mounted in the water-tight box shown in Fig. 6. The secondary leads are run from the fuse box through a duct line to the nearest manhole

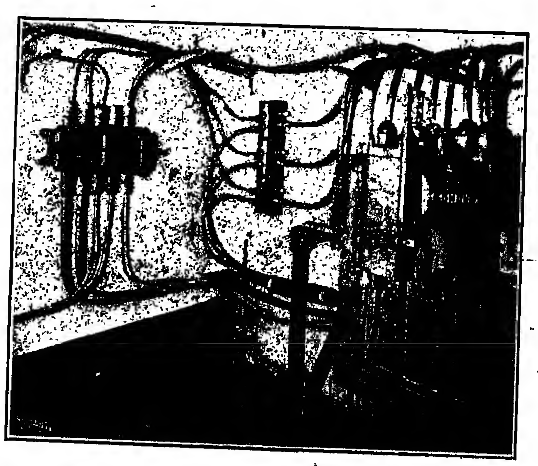

FIG. 3—TYPICAL VAULT SHOWING INSTALLATION OF CONDUIT OIL CIRCUIT BREAKER

where they enter single-phase, five-way boxes for connection to the mains.

Secondary Cable. The mains are 500,000-cir. mil, single-conductor cables installed in separate ducts. The mains on the Edison three-wire system were used as installed and the fourth conductor added to give the third phase. The general arrangement of the cables is shown in Fig. 1B.

Control (Pilot Wire) Cable. The control cable for the pilot-wire relay circuit consists of a three-conductor, No. 8, seven-strand, 600-volt rubber-insulated, lead-covered cable. This cable and the signal cable described below are placed in the same duct and follow the route of the primary circuit.

Signal Cable. The signal cable is for giving indications at the substation as to the circuit breaker positions. This cable is lead-covered, four, eight, and nineteen conductor. Each conductor is No. 12, 19-strand, 600-volt, rubber-insulated. The circuits for the indications are supplied from a 125-volt d-c. bus in the substation.

Pilot-Wire Relays and Fuse Protection. The connections used in the pilot-wire relay scheme are shown in Figs. 8 and 9. This scheme of connections was proposed by Mr. Baughn and consists in reversing the current transformer secondary in the middle phase.

With balance three-phase current in the primary, the reversal of one current transformer secondary causes the vector sum of the secondary currents to be twice

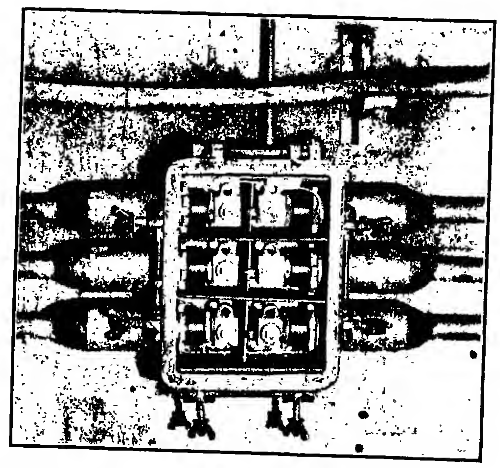

FIG. 6—SECONDARY FUSE BOX WITH COVER REMOVED

the current in any one secondary. The vector sum of the currents circulates continuously through the pilot wires and the two groups of current transformers in series. Two trip coils, one in each of the circuit breakers at either end of the primary feeder section, are connected in series through a third wire and connected to two points in the pilot-wire circuit which under normal conditions are at the same potential above ground. Consequently no current flows in the trip coils as long as there is no fault in the primary cable included in the pilot-wire relay section.

The current transformers in the secondary leads of the power transformers are connected similarly, and the resultant current added to the currents from the current transformers in the primary feeder circuit breakers.

The advantage of reversing one current transformer with respect to the other two is that protection is secured against three-phase faults and also single-phase faults between the phase having the reversed current

transformer and either of the other two phases, as well as faults to ground, which latter is the only protection secured with this type of connection if one current transformer is not reversed. The only fault which this scheme does not protect against is a short circuit between the two phases which do not have the reversed current transformers. A fault of this kind, however, will involve either the other phase or ground and open the breakers.

Another advantage of this connection is that there is no current through the trip coils, except when faults

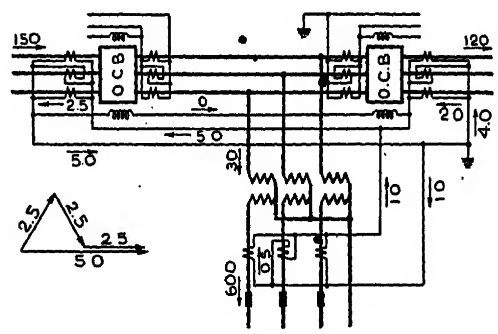

Fig. 8—Wiring Diagram Showing Currents in Pilot Wires under Normal Conditions

occur within the section protected, regardless of the resistance of the pilot wires. This allows the use of small sized pilot wires, and places no limit on the length of cable section to be protected.

When faults occur in the high-voltage feeder or trans-

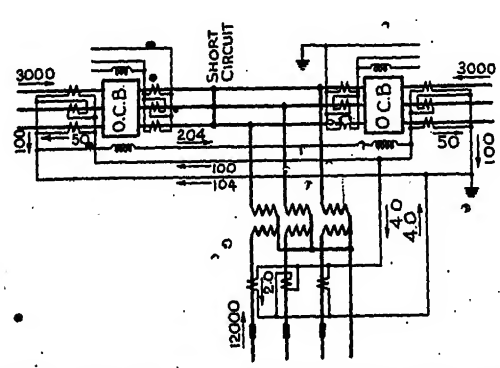

Fig. 9—Wiring Diagram Showing Currents in Pilot Wires under Short-Circuit Conditions

former, current is fed into them from both ends of the high-voltage loop feeder and from the low-voltage network. Under this condition, the currents in the pilot wires oppose each other and the trip-coil circuit provides the only path for these currents. The circuit breakers open instantly and clear the fault from the feeder. The low-voltage network continues to feed power through the one bank of transformers connected to the section of cable in which the fault occurred until the fuse in the low-voltage side of the transformer blows.

Fig. 8 shows the currents in the power cables and pilot-wire circuits under normal conditions for an assumed load of 150 amperes per phase in the high-voltage feeder and 30 amperes per phase in the primary of the transformer bank. Fig. 9 shows the conditions under an assumed three-phase short circuit in the length of cable included in the section of pilot-wire relay protec-

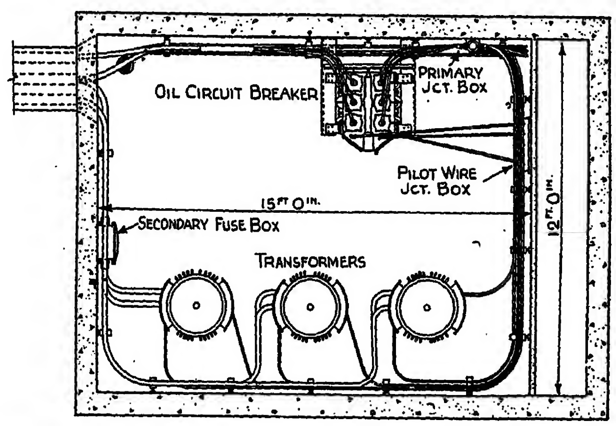

Fig. 10—Plan of Typical Transformer Vault

tion. The values of current given are for illustration only.

The size of the copper link fuses in the transformer banks varies from 800 to 1500 amperes rated capacity, depending upon the size of the transformer and its distance from adjacent vaults.

Transformer Vaults. These have been placed in the street, it having been found impractical to place them in the areaways under the sidewalks. A typical vault is shown in Figs. 10 and 12.

Natural ventilation is provided by means of steel grates in the roof at each end. Chimney action is pro-

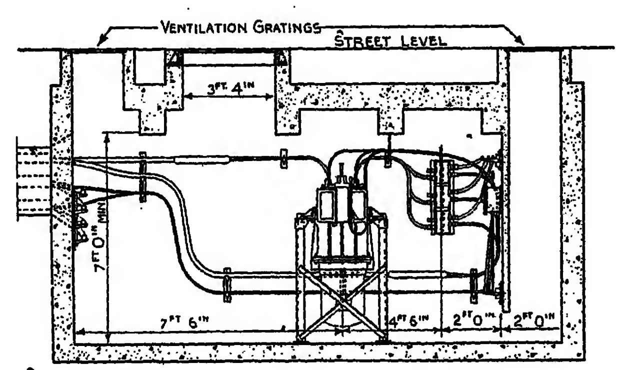

Fig. 12—Sectional Elevation of Transformer Vault Showing Oil Circuit Breaker, Junction Boxes and Arrangement for Ventilation

vided by carrying the inlet on one end to approximately 12 in. from the floor. This is shown in Fig. 12. The effective opening at each end is 900 sq. in., which takes care of a 450-kv-a. bank of transformers.

Tests Under Fault Conditions

After the network had been in operation for some time without trouble, its operation was tested under

short-circuit conditions by placing grounds and short circuits on both the primary and secondary cables at a time when the results could be observed.

Tests on Primary Cable. A test was made on the primary cable by connecting to the primary feeder through a temporary circuit breaker a short piece of three-conductor, 4000-volt cable, with one of the conductors grounded to its lead sheath. Upon closing the temporary breaker, the subway breakers on each side of the ground opened instantly, clearing the fault from the feeder. The current fed back from the secondary network was 1800 amperes, but was not sufficient to blow the 1000-ampere fuses in use. The fuses have since been changed to 800- ampere. The secondary voltage was reduced from 123 volts to 20 volts at the vault where the test was made, and from 123 volts to 110 volts at a vault 882 ft. distant.

Another test was made at the same location. It consisted of placing a three-phase short circuit on the primary feeder. The subway breakers operated satisfactorily and the current fed back from the network was 3000 amperes per phase, blowing the 1000-ampere fuses in 3.25 sec., which completely isolated the fault. The secondary voltages at the two vaults mentioned above were 20 volts and 101 volts, respectively.

Tests on Secondary Cables. One test on the secondary cables consisted of taking a short length of 500,000-cir. mil cable and driving a nail through the lead sheath into the copper. This piece of cable was attached through a temporary breaker to one phase of the secondary mains. The test was made at a point 336 ft. from one vault, 346 ft. from a second and 867 ft. from a third, each having three 50-kv-a. transformers installed. The cable with the nail in place was put in an 8-ft. length of fiber conduit. When the temporary breaker was closed, there was a slight explosion accompanied by a puff of smoke, after which the short circuit immediately cleared. Examination of the cable showed the lead was burned back about 1/16 in. all around the nail.

Other tests consisted of copper-to-copper short circuits at 208 volts using No. 2, No. 00 and 250,000-cir. mil, paper-insulated, lead-covered, 1500-volt cables. In making tests on each of these conductors, the ends were slipped half way through an 8-ft. length of conduit, and power applied. Violent explosions occurred and the short circuits burned clear in from one to two seconds.

The secondary fuses showed no signs of heating during the secondary short-circuit tests.

Voltage Regulation

The line drop compensators on the induction regulators are set to compensate to the low-voltage side of the transformer at approximately the center of the loop. No provision has been made for cross-connecting the compensators on the different feeders. The operation of the induction regulators has been entirely satisfactory, without any tendency in the regulators on the different feeders to buck each other.

Tests at various customers' service switches showed the voltage varied from 122 to 120 volts with no sudden variations of sufficient magnitude to cause flickering of lights.

Conclusions

No difficulties have been encountered on the system since its installation, and no complaints have been received to date because of low voltage or unsatisfactory motor performance.

The short-circuit tests indicated that the system functions perfectly under fault conditions.

The fuse operation proves its complete dependability and the pilot-wire control gives assurance of sectionalizing primary faults.

The very small reduction in power supply to the secondary network, due to a primary fault eliminating only one transformer bank, is a distinct value to the service rendered.

In general, there is every reason to believe that the universal type of a-c. network without network protectors, as now installed, will continue to prove its worth as a means of supplying energy to one of the highest types of electric service.

STAR-HEAT MEASURED BY ELECTRICITY

A thermometer so delicate that it can measure the heat from stars is a recent application of electricity to scientific research, according to Doctor Henry Norris Russell, noted astronomer, in *Scientific American.*

Stars invisible to the naked eye are found in a powerful telescope, which concentrates the starlight over the measuring device. The rays are carried through a small window into an exhausted receiver and fall upon a thermocouple. This consists of a junction of two tiny wires of different metals which, if heated, sets flowing a minute electric current through a sensitive galvanometer.

The wires of the thermocouple are one one-thousandth of an inch in diameter, and the whole unit weighs less than one six-hundredth of a grain. The heat from Betelguese, which sends us more than any other star, raises the temperature of the thermocouple by about one-sixtieth of one degree, but so sensitive is the galvanometer that the infinitesimal current set up causes the recording spot of light to swing through 18 inches.

Studies with the electric thermometer have already proved of value to astronomers, says Doctor Russell. More than 100 stars have been measured, and experiments thus far indicate that the apparent brightness of a star may have little or nothing to do with its heat, since much of the heat may be radiated in waves invisible as light.

ANNUAL REPORT OF COMMITTEE ON COMMUNICATION*

To the Board of Directors:

During the past year considerable progress has been made in the various branches of electrical communication engineering. The Committee on Communication submits the following report as a summary of the principal developments.

TELEPHONE TRANSMISSION

Work on improved telephone transmitting and receiving apparatus and amplifiers by the Bell System has made possible the completion of a new telephone transmission reference system, two copies of which have been built. One has been installed in New York in the Bell Telephone Laboratories, and the other in Paris under the auspices of the International Advisory Committee on Long Distance Telephony. The manufacture of these two reference systems forms a basis for world-wide agreement on the fundamental standards to be used in judging telephone transmission. A description of this equipment is given in a paper entitled *Master Reference System for Telephone Transmission,* by Messrs. Martin and Gray, scheduled for presentation at the 1929 Summer Convention.

Agreement has also been reached on the use of the fundamental unit of transmission, named the "bel." The transmission unit which has hitherto been used in this country is one-tenth the size of the bel and will therefore be known as the "decibel;" it will be continued in use in this country.

At the Winter Convention of the Institute, a paper on the subject of *Vector Presentation of Wave Filters* was presented by Messrs. Mallina and Knackmuss.[1]

TELEPHONE SERVICE IMPROVEMENTS

With the increase of approximately $275,000,000 in telephone plant investment for the country for the year 1928, toll telephone conversations increased 7½ per cent over 1927. The handling of these toll calls has been improved, both as regards speed and clearness of voice transmission. Toll calls are now handled on the average in 1.2 minutes and in over 95 per cent of the cases the subscriber remains at the telephone. Over 97 per cent of the long toll messages are carried out without evidence of transmission difficulty or interruption.

Important developments in long distance telephone communication in Canada included the completion during 1928 of direct circuits between Montreal and the maritime provinces, between Toronto and Winnipeg, and between Calgary and Vancouver.

In several of the larger cities of the United States, the practise of telling the time of day to subscribers who call the number designated for this service has been initiated.

DIAL TELEPHONY

The dial service was rapidly extended, the number of dial telephones in the United States increasing approximately 600,000 during the year, with about 18 per cent of the total stations now on this basis.

This expansion in the service requires continued development work and in the dial system areas, general use of mechanical tandem equipment is rapidly extending. This applies not only to the largest areas, but to others as well; and to step-by-step areas as well as to panel.

For areas in which step-by-step equipment is used, the dial system "B" boards have been initiated. These boards make dials unnecessary on manual "A" positions which are required to operate into dial offices. Such equipment has been found satisfactory in operation, and its use is spreading.

CARRIER SYSTEMS

The most important advance in the art of carrier current telephony over telephone lines during the last year was the extensive application of short-haul single-channel carrier systems. About 200 of these were manufactured and installed, providing approximately 20,000 mi. of carrier circuit in place of wire stringing. This system was described in detail by Messrs. Black, Almquist, and Ilgenfritz at the Pacific Coast Convention in Seattle in a paper entitled *Carrier Current Systems for Short Toll Circuits.*[2]

The important advances which have been mentioned for the past few years in the annual reports along carrier current lines were described in detail in a paper entitled *Carrier Systems on Long Distance Telephone Lines,* presented at the Summer Convention in Denver by Messrs. Affel, Demarest, and Green.[3] This paper also gave data showing the steady increase in commercial applications of these carrier systems.

In the field of carrier current communication over power lines there has been continued progress in im-

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1. A. I. E. E. Quarterly TRANS., Vol. 48, April 1929, p. 582.

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2. A. I. E. E. Quarterly TRANS., Vol. 48, January 1929, p. 117.
3. A. I. E. E. Quarterly TRANS., Vol. 47, October 1928, p. 1360.

proving designs and at the same time increasing the simplicity of operation. Additional installations of carrier telephone equipment are continuing at a normal rate, and this type of equipment has a well defined place as a reserve means of communication. In several cases, particularly on high-voltage superpower systems, power companies are making use of carrier communication for dispatching purposes. This is particularly true in isolated locations where the commercial telephone plant has not developed sufficiently to meet the requirements for continuous service.

Interesting data on power line carrier current working are contained in the following papers: *Power Line Carrier Telephony*, by Messrs. Fuller and Tolson, and *Problems in Power Line Carrier Telephony*, by Messrs. Wolfe and Sarros, presented at the Pacific Coast Convention; *Transmission of High-Frequency Currents for Communication over Existing Power Networks*, by Messrs. Boddie and Curtis, and *Carrier Current and Supervisory Control on Alabama Power Company's System*, by Messrs. Robinson and Woodcock, presented at the Atlanta Regional Meeting.[4]

Telephone Plant

An outstanding feature in the past year has been the rapid extension of toll cable, there having been placed during the year about 2500 mi. of toll cable including more than one and one-third million miles of conductor. The continuous toll cable network now extends along the Atlantic seaboard north to Brunswick, Maine and south to Greensboro, North Carolina. Westward extensions on several separate routes have been carried to St. Louis, Missouri, and Davenport, Iowa. In Canada, the Hamilton-Buffalo and Toronto-Oshawa links have been completed.

An electrical alarm system has been developed for indicating the presence of moisture in telephone cables, as shown by low insulation. This system consists of a vacuum-tube alarm device which is connected successively after a suitable charging interval for a period of approximately 60 sec. to various conductors in the cable. To avoid interference with working circuits the test is made from the midpoint of the repeating coil on phantom circuits.

For the local plant, a cable has been developed containing 1818 pairs of 26-B&S gage wires. This compares with a previous maximum capacity of 1212 pairs. The new fine gage cable will be particularly useful in conserving duct space in congested metropolitan areas.

With the increasing demand for poles used in the construction of power and communication lines, new sources of supply must be developed. Mr. Lindsay's paper *Utilization of Lodgepole Pine Timber for Poles*,[5] presented at the Summer Convention in Denver, describes the method of selecting and using lodgepole pine, which has not hitherto been used to any appreciable extent for this purpose

Telephone Equipment

A new form of information desk designed for greater convenience of reference and improved speed of answer has been developed. Improvements, particularly in connection with telephone booths and telephone station units, have been made and will result not only in better and more convenient apparatus but also in providing greater usefulness.

Improved dial system equipment particularly adapted for small private branch exchanges was made available during the year. This equipment has associated with it a small cabinet for desk mounting, which takes the place of a section of switchboard and is arranged so that the attendant's services are not required for disconnection, thus improving the over-all service and operating economies.

Private branch exchange equipment adapted to the requirements of large residences has also been developed. This equipment is intended to provide various special features which are in demand and also to introduce some improvements and simplifications.

The Bell System is experimenting with company operation of private branch exchanges with a view to improving this branch of the service.

To facilitate improvements in toll service to small outlying offices, a series of small power units particularly adapted for use in such offices to supply a few telephone repeaters, carrier terminals or telegraph circuits was developed.

Developments in Materials

The basic conception of the insulating properties of textile insulation has been investigated by the engineers of the Bell System and it has been found that by suitable purification processes, the insulating properties can be materially improved. The process and results are described in a paper entitled *Purified Textile Insulation for Telephone Central Office Wiring*[6] by Messrs. Glenn and Wood. A companion paper by Messrs. Williams and Murphy on the subject *Influence of Moisture and Electrolytes upon Textiles as Insulators*[7] was presented at the same meeting.

During the year, the use of cellulose acetate has been extended materially, both in solid form and for impregnating textiles used in telephone work. Cellulose acetate is the base of the best grades of artificial silk, is non-inflammable, and has other valuable mechanical and electrical properties.

An important development of the Bell Telephone Laboratories has been a series of alloys of iron, nickel, and cobalt, known as the "perminvars." This develop-

4. A. I. E. E. Quarterly TRANS.. Vol. 48, January 1929, pp. 102, 107, 227, and 214 respectively.

5. A. I. E. E. Quarterly TRANS., Vol. 47, October 1928, p. 1354.

6. A. I. E. E. Quarterly TRANS., Vol. 48, April 1929, p. 576.

7. *Ibid.* p. 568.

ment is an outgrowth of the earlier discovery of permalloy. The new alloy has not only high initial permeability, but its permeability is constant to a remarkable degree. Its properties indicate that it will be very serviceable in certain types of communication equipment and systems.

Airways Communications

An experimental trial of rapid telephone methods for collecting the necessary weather data is now being conducted in California by the Weather Bureau with the cooperation of the Guggenheim Foundation and the Pacific Telephone and Telegraph Company.

Another adaptation of wire services to airways communication is the use of telephone typewriter service. A number of installations has been made both for local communication at the airport and for communication beween airports.

A description of a successful system of guiding airplanes along fixed airways during fog or low visibility was given in a paper entitled *Uses of Radio as an Aid to Air Navigation,*[8] by Dr. J. H. Dellinger, presented at the Winter Convention.

Wire Line Systems for Broadcasting

In the June 1926 report of this committee, mention was made of the fact that long distance wire lines were coming into use for enabling good programs to be made available at a number of widely separated broadcast stations. This use of wire lines in connection with broadcasting has increased tremendously and the circuits regularly in use for this purpose on January 15, 1929 served more than 110 radio broadcasting stations and included more than 28,000 mi. of telephone circuit. In addition, over 40,000 mi. of telegraph circuit were also in use for control purposes.

Frequency Control in Radio

With the growth which is occurring in the number of radio channels, especially those operating at the higher frequencies (short waves), the ability to set the channels accurately in the frequency spectrum and to hold them to their assigned frequencies during operation has become of fundamental importance. Substantial contributions have been made during the past year or two in improved methods for accurately measuring frequencies and in the practical working out of the quartz-crystal oscillator control for transmitting stations. Most of the more important broadcast stations of the United States are now crystal-controlled, whereby their frequencies are maintained with an accuracy of the order of $\pm$ 50 cycles. Stations not equipped with such control sometimes find difficulty in staying within a $\pm$ 500-cycle limit. The majority of the more important short-wave transmitters of the world are likewise using crystal control but due to the imperfections of the arrangements in practical use, much interference exists between these short-wave channels. Laboratory advances made during the past year in the crystals themselves, including the manner of cutting them and of controlling their variation with temperature, as well as improvements made in the circuit arrangements for employing them, will reduce this interference as these methods become more generally available in practise.

A frequency meter has been developed which reads radio frequencies directly on an indicating instrument. This operates on a heterodyne principle in which the standard circuit is controlled by a piezoelectric crystal oscillator. The accuracy is 100 cycles in a million.

Railroad Train Radio Equipment

Further progress has been made in the application of radio communication between front and rear ends of railroad trains. In a recent installation, modulated continuous wave transmission at a wave length slightly over 100 meters is used and reliable communication is obtained. While the main principles employed remain unchanged, much has been done toward solving the design problems involved.

Transatlantic Telephony

The most outstanding phases of transatlantic telephony during the past year were the very substantial growth which occurred in telephone traffic and the extension of service to all points in Germany, Holland, Belgium, Switzerland, and Spain, and to one city in northern Africa. Certain other important points were reached also, such as Paris, Copenhagen, Stockholm, and Vienna. The extension to Paris was very important, as about 25 per cent of the traffic is to or from Paris as compared to 50 per cent to London and from 5 to 10 per cent to Berlin. On the American side, the service was extended to nine cities in Mexico, seven of the more important cities in Western Canada, and to all points in the provinces of Ontario and Quebec.

To facilitate the operation of the circuit, printing telegraph machines are now used during intervals between telephone calls for the purpose of passing "ticket information" regarding the calls and for transmitting other messages relating to the service.

In June 1928 a second two-way circuit was brought into service. The radio portion of this circuit uses very short waves, 16 to 33 meters in length, as contrasted with the long waves used for the other transatlantic circuit. The circuit is arranged to be used either independently or in combination with the older circuit, and experience has shown that the combination of long and short wave circuits gives a greater over-all reliability than with the same number of facilities operated on either long or short waves. It is expected that the increasing use and further development of transatlantic telephony will require further facilities.

During the year the research engineers of the Bell Telephone Laboratories have perfected a means of making a transatlantic telephone cable. Until now a submarine cable of this length has been impossible as

8. *Ibid.*, p. 563.

current sufficient to carry speech could not be sent by submarine cable such long distances, because the devices which are used on land for amplifying the speech currents, such as loading coils and repeaters, could not be attached to the wire under water. This cable when constructed will not only substantially increase the telephone facilities for transatlantic communication but will also provide a circuit of maximum reliability.

Transatlantic Telegraphy

One of the accomplishments in the communication field during 1928 was the successful laying of the Bay Roberts-Horta duplex loaded cable by the Western Union Telegraph Company. This cable differs from loaded cables previously laid by that company in that the loading material is Mu-metal instead of permalloy, put on in the shape of wire instead of ribbon as formerly used. In order to permit of successful balancing for duplex operation, the cable is fully loaded only on the mid-section. Towards the ends, the amount of loading material is decreased until the shore ends proper have no loading material whatever. The cable was designed to give a speed of 1000 letters per minute duplex, or 2000 letters per minute simplex, but tests made thus far upon the cable indicate that these speeds may be exceeded.

Printing Telegraphy

The expansion in the telephone typewriter service has been marked by the installation of more than 3000 printing telegraph machines during the past year. Special circuits and switching arrangements have been developed for use by the subscribers in interconnecting the lines used with these types of machines. A number of these switching arrangements has been installed to meet the special requirements of customers where a switched typewriter service somewhat similar to that given with telephone instruments associated with private branch exchanges is needed. These arrangements enable a quick communication service to be obtained and at the same time have the advantage of giving a written record of such communications.

Printing telegraph instruments of the same general character as those mentioned in the preceding paragraph are also being used in rapidly increasing numbers by the commercial telegraph companies, about 6000 having been installed during the past year. In this field for the transmission of telegrams the principal application of the machines is on lines connecting main and branch offices of the telegraph company with each other and with customers' establishments. The major switching problem involved is the concentration of numerous lines of this character for efficient traffic handling by a group of central office operators. Equipment recently installed permits the concentration of one hundred or more lines so as to be accessible to any required number of operators.

Excellent progress was made during the year in the joint development by the Teletype Corporation and the Western Union Telegraph Company of a high-speed ticker capable of operating at 500 characters per minute. Installation of this new ticker and its associated equipment will take place during 1929 in the New York Stock service. The same machine will be used by the Telegraph Company and by the New York Quotation Company, which is the official operating company of the New York Stock Exchange.

In the field of trunk-line message circuits between cities, which are usually operated by high-speed multiplex printing telegraph apparatus, an important development of the past year has been the extension of metallic circuit working. Most earlier attempts have required the use of two line wires for each metallic circuit. In the system now successfully used by the Western Union Telegraph Company, three high-speed metallic circuits are obtained from each group of four-line conductors without carrier frequencies.

Facsimile Transmission

A considerable increase in the use of the telephotography service of the Bell System resulted from commercial arrangements made during the year. Under these arrangements, the leading telegraph companies collect from and deliver to the public photographs, diagrams, and other facsimiles which are transmitted over the telephotograph circuits.

The Westinghouse Electric and Manufacturing Company reports that an apparatus has been developed for facsimile picture transmission which is considerably more rapid than the existing commercial systems. It is expected that this will be available for sale in a comparatively short time.

Television

What appears to have been the most significant advance in television made during the year was the development of equipment for the transmission of images of outdoor scenes, illuminated by sunlight. A public demonstration of this equipment was given at the Bell Telephone Laboratories on July 12, 1928, at which time action scenes, such as a tennis player going through his strokes, were successfully transmitted.

An improved photoelectric cell of greater sensitivity and a more efficient optical system for scanning were employed.

Sound Pictures

The year 1928 saw wide extension of sound-picture systems throughout the theaters of the United States, and the equipment of the important studios with recording apparatus for producing both disk and film records. The light-valve method of recording sound on films was introduced commercially, and altogether, during the year about 2000 sound projector equipments were put into use in motion picture theaters in the country. Also improvements in frequency range of recording and reproduction were made during the year, and electrical systems for the accurate speed control of the projector equipment were utilized in the reproduc-

ing-systems. Field equipment, as distinct from studio equipment, was developed for recording, as was also portable projector equipment. The first educational sound-picture film, a production of the Bell Telephone Laboratories, made its appearance during the year, developing the principles of carrier-current telephony, particularly modulation and filtering. This film was projected before several scientific and educational audiences.

Municipal and Protective Signaling

There has been a considerable increase in electrical signal devices for traffic control. Synchronous control of such signals along a street or throughout a section appears to be growing in favor. Progress has been made in the application of signals which normally permit a steady flow of traffic along a main thoroughfare but subject to manual or automatic reversal on the approach of traffic from a side or cross street.

For small fire alarm systems, an improvement of the past year has been the introduction of electrical sirens that can be coded satisfactorily. The various defects of former types have been overcome to a great extent, and further development will lie probably in provisions for emergency power supply to ensure operation even if the public electrical supply should be deranged.

An increase is noted in the use of police signaling systems. The older local battery systems are being converted to central energy operation in some cases. There is also a tendency of banks and other financial institutions to connect their protective circuits and vault alarm systems to the police signal circuits. Some expansion has also taken place in the interurban teletype signaling systems mentioned in last year's report.

Abridgment of

A New Automatic Synchronizer

BY F. H. GULLIKSEN[1]

Associate, A. I. E. E.

Synopsis.—The fundamentals of automatic synchronizing are discussed, and the requirements which must be met by the ideal synchronizer outlined. The design and principle of operation of two different models of a newly developed automatic synchronizer are described. The paper treats of the method by which, for any frequency difference within limits of present operating practise, either model of the synchronizer will cause the closing coil of the circuit breaker to be energized in advance of synchronism by a time equal to that required to close the circuit breaker. The closing coil of the circuit breaker is therefore energized when the phase displacement between the voltages of the two systems to be synchronized is such that, assuming the frequency difference between the two systems remain constant during the short time required to close the breaker, the breaker contacts will always be closed at the instant of zero voltage phase displacement. The reasons for the excellent performance of these automatic synchronizers, even when applied to connect systems with very erratic frequencies, are outlined. A series of tests is referred to, showing the superiority of automatic synchronizing in comparison with manual synchronizing, and the results obtained with the new synchronizer models in a generating station with propeller type waterwheels are described.

* * * * *

Fundamentals of Synchronizing

THE synchronizing of a-c. generators is one of the most exacting duties required of an operator in a manually-operated generating station.* When the operator is bringing a new unit on the line he knows that a false move may damage a machine worth hundreds of thousands of dollars, or at least may cause on the system, disturbances so severe that important synchronous load connected to it may fall out of step. For this reason, the influence of the human element is more pronounced in manual synchronizing than in most other generating station operations where the result of a faulty move will not be as disastrous. It has long been the trend within the field of electrical operations to try to eliminate the human element and substitute for this a mechanical device which is not affected by nerves and human emotions, and which can always be relied on to operate at the topmost rate of efficiency and performance. This is even more the case when the mechanical device will do a better and quicker job than a skilled operator.

It is a well-known fact that due to the synchronizing force, it is possible to connect two synchronous generators even if a frequency difference exists between the two machines. Small generators can thus safely be connected to a large system at frequency differences as high as ¼ cycle per second. To keep the equalizing current within permissible limits, however, the case requires that the breaker contacts be closed at the point of zero voltage phase displacement. The underlying idea of the design of an automatic synchronizer is therefore to provide an apparatus that will close the breaker connecting two sources to be synchronized if the frequency difference between the two sources is below a predetermined value to be chosen for each particular application, and to accomplish this at such a moment that, independent of the instantaneous frequency difference, the breaker contacts will always engage at the instant of zero phase displacement between the voltages. The factor that complicates the design of an ideal automatic synchronizer is the time element of the circuit breaker. There is always a

1. Control Engineering Department, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

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certain time required from the energizing of the closing coil of a circuit breaker until the breaker contacts close. This time is practically constant for a definite breaker, but varies for different types and sizes of breakers from 0.2 second to 0.6 second. In most synchronizing applications the frequency of the machine to be connected is erratic, so that the synchronizer at times will have to close the breaker at an instantaneous frequency difference equal to the maximum frequency difference for which the apparatus is adjusted to operate; and at other times it will have to close the breaker when the frequency difference is practically zero. To obtain breaker closure at zero phase angle displacement for any frequency difference within the selected synchronizing zone, the synchronizer must therefore be designed to energize the breaker closing coil at such a point in advance of synchronism that

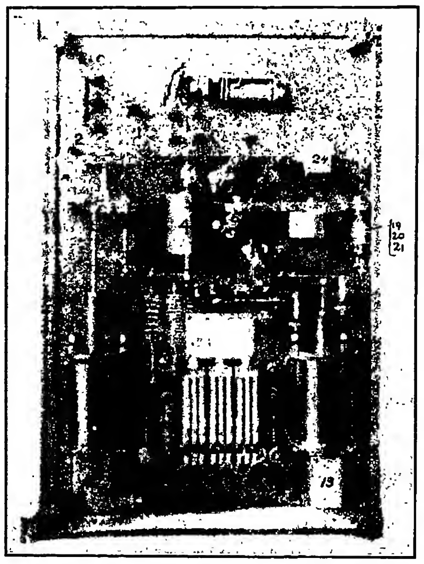

FIG. 1—FRONT VIEW OF THE AUTOMATIC SYNCHRONIZER WITH COVER GLASS REMOVED

the amount of advance, measured in degrees phase angle displacement, is always proportional to the instantaneous frequency difference.

This proportional advance feature is incorporated in the two models of the automatic synchronizer described in this paper.

DESIGN OF THE NEW AUTOMATIC SYNCHRONIZER

In Fig. 1 is shown a front view of the new automatic synchronizer with the front glass cover removed. Of this apparatus two different models Type XY-11 and Type XY-12 are available. The design and appearance of the two models are quite alike, but the principle of operation is different, one model,—the Type XY-12,—being designed especially for applications with very erratic frequencies.

From Figs. 2 and 3 may be seen that the two coils 11 and 14 are connected in series across the beat voltage between the two systems to be synchronized, so that the voltage across the coils is zero when the phase displacement between the system voltages is zero, and 220 volts when the phase angle displacement is 180 deg. Provided the voltages of the two systems are sine waves, the voltage across the coils will vary as a sine curve.

The synchronizer consists essentially of two independent coil-core lever systems and four d-c. relays of the telephone type. The one lever system is comprised of dashpot 12, coil 11, core 10, lever 22, fulcrum

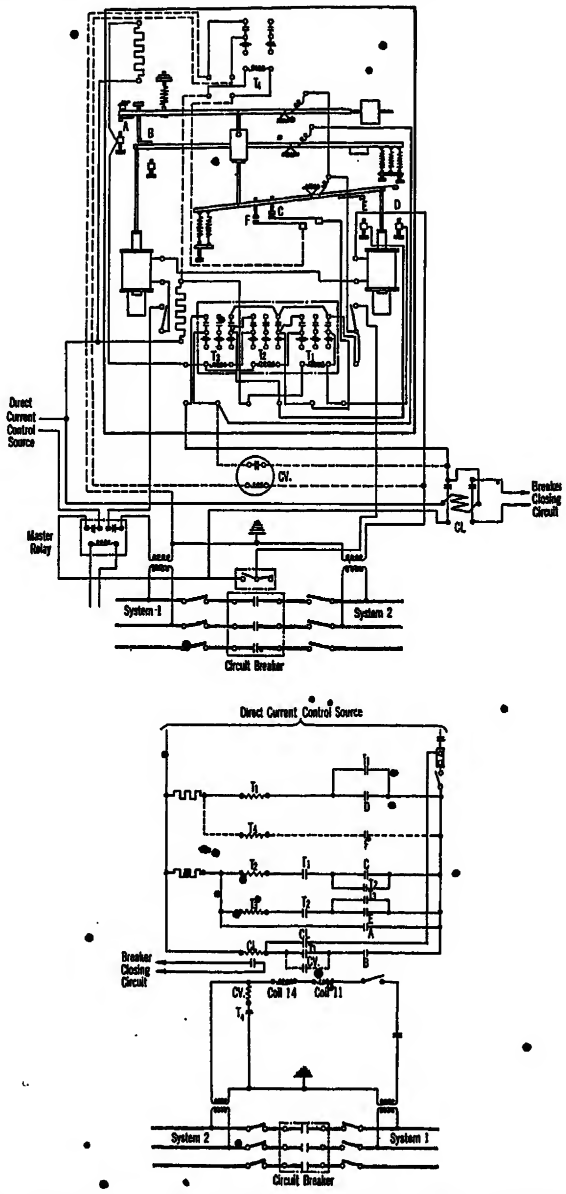

FIG. 2—DIAGRAM OF CONNECTIONS AND SCHEMATIC DIAGRAM FOR AUTOMATIC SYNCHRONIZER TYPE XY-11

6, and springs 19, 20, 21. Lower contact B is mounted on lever 22. The pull of the springs 19, 20, and 21, and the pull of coil 11 on core 10, are so proportioned that for phase angles up to 50 deg. the amount of travel of lower contact B, in relation to the highest position of contact B, is proportional to the phase-angle displacement between the two system voltages. For phase angles exceeding 50 deg., lever 22 is resting against stop post 5. The amount of damping in dashpot 12 is

small, and for this reason the position of lower contact *B* will be dependent only upon the instantaneous phase-angle displacement and will not depend upon the rate of change of the phase-angle displacement; *i. e.*, the instantaneous frequency difference. How this performance is obtained through the interaction between the two coils 11 and 14 is outlined in the unabridged paper.

The other lever system operates mechanically, independent of the above described lever system, and consists of two lever assemblies connected by means of an air dashpot 4. Lever 3, supported by fulcrum 23, is balanced by means of spring 1 and counterweight 24 to barely touch stop post 2. Upper contacts *A* and *B* are mounted on lever 3. Lever 17 is supported by fulcrum 18, and balanced by means of springs 7 and 8 against the pull exerted by coil 14 on core 15. Core 15 and right-hand side of lever 17 will be in the lowest position when the phase displacement angle between the two system voltages is 130 deg. If the angle is reduced core 15 will travel upwards and tend to assume a position in relation to its highest position proportional to the phase angle displacement. The movement of lever 17 is damped by means of dashpots 4 and 13. Due to this damping the position of core 15 and consequently also lever 17 will be lagging, if a frequency difference is present, in relation to the position lever 17 would assume if the frequency difference were zero. The amount of lag when the phase displacement is decreased from 130 degrees towards zero will be proportional to the frequency difference and the effect of this is to reduce the amplitude of travel of core 15 and its connected lever 17 by an amount which for low values of frequency difference will be proportional to the frequency difference. Consequently contacts *C* and *F*, which may be adjusted to close at 30-deg. phase displacement if the frequency difference is zero, will close at a point nearer to zero phase displacement if the frequency difference is increased, and for a certain definite frequency difference contacts *F* and *C* will not close during one revolution of the phase displacement vector.

When the phase displacement between the two system voltages is decreasing, core 15, as previously mentioned, will travel upwards with a velocity proportional to the instantaneous frequency difference so long as the frequency difference is comparatively low; *i. e.*, of an order of three cycles or less. Since the plunger of dashpot 4 is connected to lever 17 the velocity of the downward movement of the plunger will be proportional to the instantaneous frequency difference. When plunger 4 is being moved downwards, the dashpot 4 will exert a certain downward pull on the left-hand side of lever 3, and consequently lever 3 will rotate counter clockwise until the pull of dashpot 4 is balanced by the increasing tension on spring 1. The pull of dashpot 4 on lever 3 is proportional to the velocity of travel of plunger 4. The extension of spring 1 is proportional to the tension of the spring, and for this reason the angular movement of lever 3 is proportional to the pull of dashpot 4; furthermore, proportional to the velocity of travel of plunger 4, and consequently proportional to the instantaneous frequency difference between the two systems to be paralleled. For this reason, when the phase displacement vector passes through the zero point, upper contacts *A* and *B* will have assumed a position in relation to their highest position which will be proportional to the instantaneous frequency difference. Consequently, when the frequency difference is zero, contacts *B* will close at the point of zero phase displacement. For any definite frequency difference, the contacts will close at a point in advance of synchronism, the amount of advance being proportional to the instantaneous frequency difference.

By adjusting the amount of damping in dashpot 4, the synchronizer can be adjusted to energize the closing relay of any circuit breaker connecting two systems to be synchronized at such a point in advance of synchronism, that, allowing for the time element of the breaker, the breaker contacts will close at the point of zero phase displacement, assuming that the closing time of the breaker is practically constant, and further assuming that the frequency difference does not change during the short time required to close the circuit breaker.

The XY-11 synchronizer is arranged so that the breaker will be closed if the frequency difference during the last 90 deg. of the phase rotation does not exceed the selected lockout frequency difference, while the XY-12 synchronizer will connect the breaker and synchronize the two systems if the frequency difference at a point 35 deg. ahead of synchronism is lower than the selected lockout frequency difference. Thus it may be seen that the XY-12 synchronizer is especially well adapted for application with very erratic frequencies.

Lower contact *A* is a stationary contact mounted on the base of the synchronizer. For a definite setting of lower contact *A* there is a definite frequency difference above which contacts *A* will engage during one rotation of the phase displacement vector. This feature is used in the lockout scheme for the XY-11 synchronizer as shown in Fig. 2 which is arranged so that whenever contacts *A* have been engaged it is necessary for the phase angle to once exceed 100 deg. before the synchronizer again will be able to close the paralleling breaker.

Assuming that the proper connections to the two systems have been made, and that the master relay connecting the synchronizer to the control circuits close when a frequency difference of five cycles exists between the two systems, none of the relays, T_1, T_2, T_3, will be energized because lever 17, due to the damping effect of dashpots 4 and 13, will never come into a position to close contacts *D*. When the frequency difference is reduced to approximately 3 cycles, contacts *D* will engage, closing relay T_1 which will seal itself in. Nothing further happens until the frequency

difference is reduced to ½ cycle. At this frequency difference, contacts C engage at approximately zero phase displacement and relay T_2 is closed and sealed in. At a point 260 deg. ahead of synchronism, contacts E will close and relay T_3 will be energized and sealed in.

Supposing now the frequency difference is lowered to $^1/_7$ cycle and that contact A has been adjusted just not to close at this frequency difference, then the breaker closing relay will be energized at the proper phase advance when contacts B engage, and the breaker main contacts will engage at the point of zero phase displacement. If, however, the frequency difference should happen to increase above $^1/_7$ cycle, then contacts A will engage before contacts B close, relays T_2 and T_3 will be shunted by contacts A and opened, and in this manner synchronizing is prevented.

The schematic diagram of connections for the type XY-12 synchronizer is shown in Fig. 3. For frequency differences below three cycles, contacts D will close at some point 100 to 180 deg. out of phase, and energize relay T_1, which seals itself in through the back contacts of relay T_2. As long as the frequency difference is above the selected lockout frequency difference, contacts B will close before contacts C close, and relay T_2 will be closed, thus opening relay T_1. Contacts E which close simultaneously with contacts D are connected to shunt the relay T_2 to be sure that relay T_2 will open once during each phase rotation. If the instantaneous frequency difference at a point 35 degrees ahead of synchronism is lower than the slected lockout frequency difference, relays T_2 and T_3 will be closed, provided relay T_1 has already been closed; hence the breaker closing relay will be energized and the breaker will be closed. The operating sequence under these conditions is: Contacts D close approximately 260 deg. ahead of synchronism, and close relay T_1 which seals itself in across the back contacts of relay T_2. At a point within 60-deg. phase displacement, dependent upon the frequency difference, contacts C close and operate relay T_3 which seals itself in, while one pair of the contacts of T_3 parallels the T_2 back contacts in series with relay T_1. When the phase displacement is further reduced, contacts B close at the proper phase advance proportional to the instantaneous frequency difference, and energize relay T_2 which completes the closing circuit of the breaker closing relay so that the breaker will close and synchronize the two systems.

In Figs. 2 and 3 is shown an external relay marked $C\,V$. This relay is applied in addition to the synchronizer when the apparatus is used in applications where the breaker is not always the first tie between the two systems to be synchronized. When the breaker is not the first tie, the frequency difference between the two sides of the breaker is zero, and hence no phase rotation will obtain. The telephone relays of the synchronizer would therefore not become energized if the external $C\,V$ relay were not applied. This relay has a time delay and is energized through the contacts of relay T_4 which is closed whenever contacts F are closed. Contacts F are adjusted to close within 15 deg. phase angle displacement, and the $C\,V$ relay will therefore close its contacts if the phase angle displacement remains within the 15 deg. limit for a time interval exceeding the time delay of the relay.

Comparative Tests Between Hand Synchronizing and Automatic Synchronizing

A series of tests was made with the XY-11 type syn-

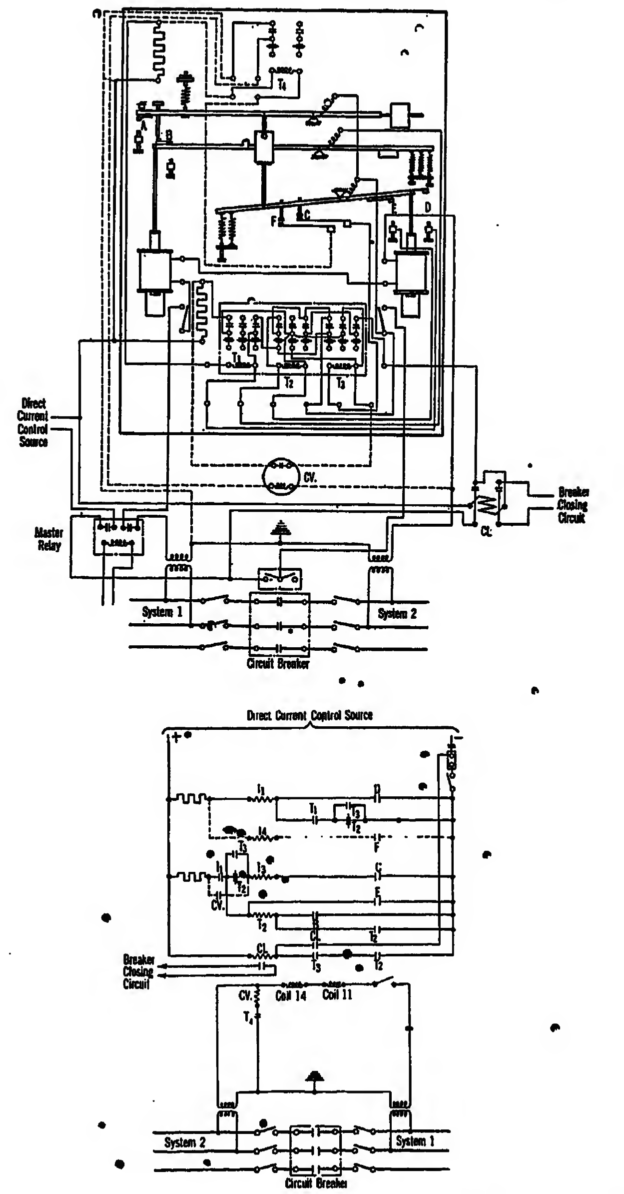

Fig. 3—Diagram of Connections and Schematic Diagram for Automatic Synchronizer Type XY-12

chronizer to determine the performance of the synchronizer and compare it with the performance of a skilled operator. A 3000-kv-a., 25-cycle, hand-regulated three-phase motor-generator set was arranged to be synchronized with a 25-cycle test circuit. A quick operating relay (closing time 0.009 sec.) was used as a closing indicating relay and was connected so that it would operate when the main contacts of the circuit breaker

engaged. This relay was held in the hand of one of the men conducting the tests, and the position of the synchronoscope pointer was read by him at the instant he felt the indicating relay operating.

The result of the tests is shown in Fig. 4, which gives the percentage of the total number of operations for which the circuit breaker contacts would close at a certain voltage phase displacement.

The results for manual operation show that an operator is liable to close the circuit breaker too late. This would be even more the case for applications with erratic frequency; and for such applications, the comparison between automatic synchronizing and hand synchronizing would be still more favorable for the

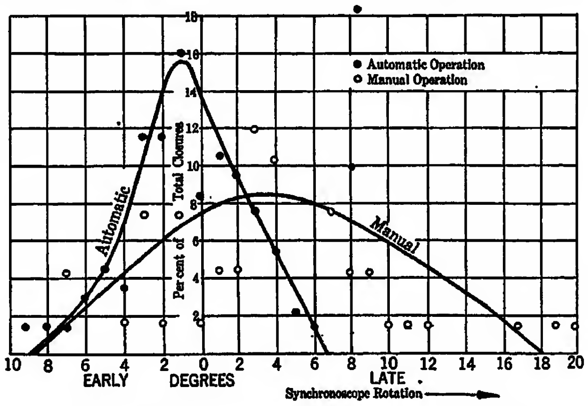

Fig. 4—Results of Comparative Tests

automatic synchronizer. From Fig. 4 may be seen that the automatic synchronizer would never close the breaker main contacts at a wider angle than 9 deg., while the operator happened to close the breaker 20 deg. late.

Field Tests

Through the courtesy of Kentucky Hydro Electric Company a series of tests were made with the two automatic synchronizer types XY-11 and XY-12 at the hydroelectric generating station at Dam No. 7, Kentucky River. This station is equipped with three generators, driven by propeller type water wheels rated 1000 hp., 150 rev. per min. at 15 ft. normal water head. The generator rating for each unit is 850 kv-a. at 80 per cent p. f., 60 cycles, 150 rev. per min. The inertia of the units is low and due to the inherent characteristic of the hydraulic equipment, the frequency of the generator to be synchronized is very erratic in spite of the excellent condition of the installed governor equipment. The automatic switching equipment of the station was arranged so that any one of the three generating units could be started up by a push-button on the switchboard or by means of supervisory equipment controlled from a distant dispatcher office. After a unit had been started up, the automatic synchronizer was given control when the speed of the generator was high enough to allow the generator voltage to build up to normal. The time interval from the moment when a unit was started until the synchronizer was given control was practically constant for each individual unit, but showed some variations for the three different units due to the various adjustments of the time delay of the voltage relays connected to give the synchronizer control. With the XY-11 synchronizer in service, 19 different synchronizing operations were made, while 25 different synchronizing operations were made with the XY-12 synchronizer in service. By means of a stop watch the total synchronizing time, from the start of a unit until breaker closure was measured. With the type XY-11 synchronizer in service the average time required to synchronize a machine was 91.5 sec.; the minimum time was 45 sec., and the maximum time 240 sec. With the XY-12 synchronizer in service, the average synchronizing time was 68 sec., the minimum time 45 sec., and the maximum time 140 sec. It should be noted that the time required to bring the machines up to synchronous speed, approximately 40 sec., are included in above time intervals. During the tests the machine frequency was very erratic; in fact, the synchronoscope pointer was never seen to rotate at uniform speed for one full revolution, and the frequency difference seldom remained within the selected lockout limit (1/5 cycle) for more than 10 sec. Due, however, to the proportional advance incorporated in the synchronizer models, the synchronizer would never close the breaker farther off synchronism than 15 deg. The average closing point for the XY-11 synchronizer was found to be at 2.9 deg. phase displacement, and th[illegible]osing point for the XY-12 synchronizer was found to be at 4.8 deg. phase displacement.

The type XY-12 synchronizer was permanently installed in this station, and synchronizing tests were made with the installed equipment to determine the time required to synchronize the whole station to the line. During the tests the push-buttons of all three units were pressed simultaneously. Unit No. 1 would then start up. As soon as unit No. 1 reached normal voltage the synchronizer would be connected and the machine synchronized properly with the line. Units Nos. 2 and 3 would then start up simultaneously, and unit No. 2 was synchronized when the proper synchronizing conditions obtained. When unit No. 2 went on the line, the synchronizer was switched over to unit No. 3 which would be synchronized. During 7 different tests it was found that the type XY-12 synchronizer would connect all three generating units to the line in an average time of 159 sec., while the maximum synchronizing time was found to be 194 sec., and the minimum synchronizing time 119 sec. It should be noted that these data cover the time required to bring all three units up from zero speed to normal speed and to synchronize each unit individually with the line.

Acknowledgment

The writer wishes to express his appreciation for valuable suggestions received from J. H. Ashbaugh and H. C. Nycum.

Contact Wire Wear on Electric Railroads[1]

BY I. T. LANDHY[2]

Non-member

Synopsis.—It is the purpose of this paper to present such data on the subject of contact wire wear as the electric operation of four railroads has made available. Design of overhead system and pantographs, lubrication of pantograph shoes, presence of steam locomotives under catenary, ice on contact wire, condition of roadbed, speed of trains, and amount of current collected at pantograph shoe all have a bearing on the rate of wear, the relative importance of each of these factors being a moot question. The four railroads contributing are the New York, New Haven and Hartford, the Chicago, Milwaukee, St. Paul and Pacific, the Pennsylvania, and the Illinois Central.

* * * * *

General Description

The New Haven's initial electrification in 1907, of approximately 21 route mi. of four tracks from Woodlawn, N. Y. to Stamford, Conn. was extended in 1914 from Stamford to New Haven, Conn., with about 39 route mi. of four tracks.

High-speed suburban and through passenger, and heavy freight traffic in the electrified zone are supplied with 11,000-volt, 25-cycle, single-phase, a-c. power. Speeds up to 70 mi. per hour are attained, the maximum weight of a train being 3800 tons. In addition, there is still a number of steam trains operated, these being mostly heavy-tonnage freight trains. A considerable steam traffic was operated in the electrified zone initially, but since, has been supplanted almost entirely by electric except for that mentioned above.

The contact wire, which is 4–0 grooved of 40 per cent conductivity bronze, normally varies from 16 to 22 ft. above top of rail, the gradient at points of change averaging about 1 per cent. It is supported from an auxiliary 4–0 grooved copper wire at 10-ft. intervals by malleable iron or bronze clips. The contact wire tension varies between 100 lb. and 3800 lb. depending upon the temperature.

The pantograph shoes are of pressed steel, those for the larger locomotives of No. 11 U. S. gage, and for the multiple-unit equipment and smaller locomotives, of No. 14 B. W. G. Normal pantograph pressure on the wire is about 18 lb., increasing to about 25 lb. when the pantograph is traveling down, and decreasing to about 10 lb. when traveling up. Although lubrication was attempted for a time, the shoes are normally not lubricated. The normal maximum current collected is about 200 amperes per pantograph shoe.

Each unit of motive power used in road service carries two pantographs, although normally but one is used at a time. A considerable number of both passenger and freight trains is double headed, which involves two pantograph passes for each movement of such trains. Multiple-unit trains are normally made up with a ratio of one motor car to each two trailers. An average of 25,000 pantograph passes per year per track has been assumed.

The Milwaukee began electrical operation in 1915 of 441 route mi. of line, between Harlowton, Mont. and Avery, Idaho, and in 1919 of an additional 218 route mi. between Othello and Seattle-Tacoma in Washington.

The services operated electrically are through passenger and freight. D-c. power at 3000 volts is supplied the locomotives, about ten per cent of that supplied being returned through regenerative braking.

A ½-in. Siemens-Martin steel messenger supports two parallel 4–0 grooved copper contact wires by means of loop hangers alternately clipped to one and then the other. The height of contact wire above top of rail varies from 17 ft. to 24 ft. 2 in.

Each pantograph consists of two independent steel shoes with hard-rolled copper contact strips. The strips on each shoe are separated to provide a trough between them for the lubricant. The pantograph pressure on the contact wire is 30 lb., making the pressure per shoe equal to 15 lb.

The Pennsylvania's suburban service between Philadelphia and Paoli, Pa., about 20 route mi., was electrified in 1915, and between Philadelphia and Chestnut Hill, about 12 route mi., in 1918.

The inclined catenary type of construction in use between Philadelphia and Paoli consists of a ½-in. steel messenger[3] supporting a 1–0 round copper auxiliary messenger at 30-ft. intervals, the 3–0 grooved phono-electric contact wire being suspended from the auxiliary messenger by clips spaced at 15-ft. intervals, staggered with respect to the hangers. The construction in use between Philadelphia and Chestnut Hill is similar to the above except that the auxiliary messenger is a 2–0 grooved copper wire. Normal contact wire height is 22 ft. above top of rail, the gradients down to lower heights varying between 0.12 and 1.2 per cent.

These electrified tracks are used principally by multiple-unit suburban trains, a relatively small

1. This paper was written in collaboration with Sidney Withington, Electrical Engineer, N. Y., N. H. & H. R. R., R. Beeuwkes, Electrical Engineer, C. M. St. P. & P. R. R., J. V. B. Duer, Electrical Engineer, Pennsylvania R. R., and W. M. Vandersluis, Electrical Engineer, I. C. R. R.

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3. Approximately 40 mi. of the steel messenger has been replaced by ⅝-in. high-tension bronze cable, due to the corrosion of the former by locomotive gases.

electric locomotive mileage being made for experimental purposes, also. Steam locomotives are used in the electrified territory, too. A-c. power is supplied at 11,000 volts, the multiple-unit cars drawing normally a current of 20 amperes with a maximum of 80 amperes during acceleration. The schedule speed of these trains is high and the station stops are relatively close together so that maximum speeds well up toward 60 mi. per hr. must be attained.

The pantograph, the shoes of which are of mild steel, have been designed for as low an inertia as possible. Normal pressure against the contact wire is 18 lb.

The Illinois Central, in 1926, electrified its suburban service between its Chicago terminal and Matteson, Ill., Blue Island, Ill., and South Chicago, a total of approximately 39 route mi.

The catenary, except for yards, sidings, and crossovers, consists of a 0.81-in. composite copper-copperweld messenger cable supporting, at 15-ft. intervals, a 3/8-in. auxiliary messenger cable which in turn supports two 4–0 grooved copper contact wires. These are in the same horizontal plane, each wire being clipped to the auxiliary messenger at 15-ft. intervals, the clips being staggered with respect to the hangers and clipped to first one and then the other contact wire. In the denser traffic zone, north of the junction with the South Chicago branch at 67th Street, two 3–0, 80 per cent conductivity, grooved cadmium-bronze contact wires are used, each wire suspended at 20-ft. intervals from a 1/2-in. auxiliary messenger cable, the main messenger being the same. The yard catenary is composed of a 4–0 grooved copper contact wire suspended by rigid hangers from a 3/8-in. phono-electric bronze messenger. Normal contact wire height is 22 ft. with an allowable gradient of 1 per cent down to lower heights to clear overhead obstructions, minimum height being 16 1/2 ft.

D-c. power at 1500 volts is supplied the multiple-unit suburban trains which consist of from two to eight cars. Speeds up to 65 mi. per hr. are attained in order to maintain a fast schedule with fairly frequent stops. The accelerating current averages 770 amperes per pantograph, the normal running current being 200 amperes. There is only a small amount of steam operated traffic, (mostly switching), directly under the wires, but the through passenger and freight tracks are adjacent to the suburban tracks so that locomotive gases are more or less always present.

The pantographs have, in general, galvanized sheet steel bodies faced on the contact surface with hard-rolled copper strips, but a few bodies are of aluminum. The life of contact strips is approximately 10,000 mi. Normal pantograph pressure is 22 lb. All pantographs are lubricated, a trough between the contact strips holding the grease.

The multiple-unit cars operate in pairs, one being a motor car carrying two pantographs, only one of which is normally in use, and the other a trailer.

Discussion

The design of the catenary system is important, aside from its functions of supplying a contact plane for the current collector and a distribution system for the power, in determining the rate of wear of the contact wire or wires. It will be noted that in each of the four systems described special precaution has been taken to obtain flexibility in the contact plane. The line must be flexible enough to insure intimate contact between wire and pantograph and yet not so flexible as to permit the formation of a large wave ahead of the pantograph as it moves forward. The requisite flexibility can best be obtained by staggering the points of support of the contact wire with respect to the messenger, while at the same time damping out the unwanted harmonic wave ahead of the pantograph by means of as high a tension in the contact wire as it will permit. It will be readily seen that a wave propagated ahead of the pantograph has no serious effects as long as its rate of propagation, the speed of the pantograph, and the mass of the contact plane remain of the same relative magnitude; but let any one of these factors change and the smooth passage of the pantograph under the contact wire is interrupted to the mutual detriment of both. Thus, it is always at those pull-offs where the free vertical movement of the wire is restricted and at such points as have a more-than-normal concentration of weight that accelerated contact wire wear is found. A large proportion of any contact-wire system wears slowly and uniformly, yet it is the small proportion of places where the wear is accelerated that require replacement soonest. At gradients in the contact system the inertia of the pantograph causes a greater or lesser pressure on the wire, greater if moving down and lesser if moving up. At a certain pressure, which obviously should be the normal pressure, the wear will be a minimum, any greater or lesser pressure resulting in increased wear; if greater, due to increased friction, and if lesser, due to increased burning caused by insufficient contact.

Pantograph design resolves itself into a judicious composition of the following essentials: (1) sufficient current collecting surface; (2) light weight moving parts; (3) sufficient uniform upward pressure; and (4) freedom from friction in the bearings. The effect of the first will be taken up further on. The necessity of having all moving parts as light in weight as possible is apparent. All changes in grade of the contact wire require that the pantograph follow them, and, in order to minimize the wear, especially at the *change* in grade, the inertia of the pantograph must be small. A sufficient uniform upward pressure must be present to permit of current collection without arcing. Friction in the pantograph bearings may be classed as additional inertia since its effect is the same.

It is probable that if the contact surface of the pantograph were of some metal dissimilar to that in the contact wire a lower rate of wear of the latter would result, on the theory that the coefficient of friction

between dissimilar metals is lower than that between similar metals.

The question of lubricating the pantographs produces a diversity of opinion. The New Haven and Pennsylvania do not lubricate, while the Milwaukee and Illinois Central do. The effect of lubrication *per se* will be taken up at length further on. Just now it may be well to point out that the decision to lubricate or not is probably influenced by the presence under the wire of steam locomotives. The experience of the Milwaukee shows that locomotive smoke and the sand blown from the stack of oil-burning locomotives in sanding the fire-tubes adheres to the grease film on the wire forming an actively abrasive surface. No doubt some similar action would be present in localities where dust or sand storms are prevalent. On lines such as the New Haven's and Pennsylvania's where a considerable steam traffic passes directly beneath the contact wire, the presence of grease on the wire might increase the wear.

Intrinsically, lubrication plays an important role in reducing wear. Extended measurements and observations on the Milwaukee show that, on long tangents where the contact wire is in the middle of the pantograph the greater part of the time, the lubricant becomes depleted and wear is increased. On the other hand, on curves where the pantograph is wiped across the contact wire due to the chord type of catenary employed, the wear is less, the lubricant from the ends of the pantographs being distributed over the whole surface. A comparison of contact wire measurements shows that there is approximately 30 per cent more wear on tangent track than on curves.

Further evidence of the effect of lubrication is found in tunnels. Here, where the wires are sheltered from sun, rain, dust, and frost, the wear is approximately one-half that on exposed tangent track. Other factors may contribute to this end, but that the shelter of the tunnel is the dominant one is shown by the fact that where water drips from the tunnel roof the wear is greater. The limited experience of the Illinois Central corroborates these observations.

The presence of steam locomotives under the wires, aside from the abrasive deposits left by them, produces a certain corrosion, small though it may be, of the contact surface. Any pitting from this cause removes a small amount of the wire and leaves a roughened surface which is abrasive to a degree. The total effect is probably insignificant.

Ice on the wires separates them from the pantograph, causing small arcs to be drawn. The pits formed by these arcs are substantially the same as those mentioned in the preceding paragraph except that they are larger and hence more injurious. Accelerated wear is in progress at the pitted spots until they are worn smooth again. The kind of service operated is largely influential in determining the total effect of ice deposits on contact wire wear. With frequent suburban service providing less time for the deposits to form the effect is probably of small moment, especially, as on the Illinois Central, when there is danger of the formation of sleet all pantographs are raised. With a relatively small number of pantograph passes a day as on the Milwaukee, particularly when the territory served is subject to more or less frequent sleet storms, the wear occasioned by such deposits is important. It may be said, then, that the burning, and therefore the wear, due to ice on the wire is less per pantograph pass where the frequency of the passes tends to keep the surface of the wire clear.

The condition of the roadbed affects the riding qualities of the cars, which in turn affect the pantographs carried by them. A sudden drop due to a low rail joint or frog point may cause the pantograph to leave the wire momentarily, drawing an arc, and producing

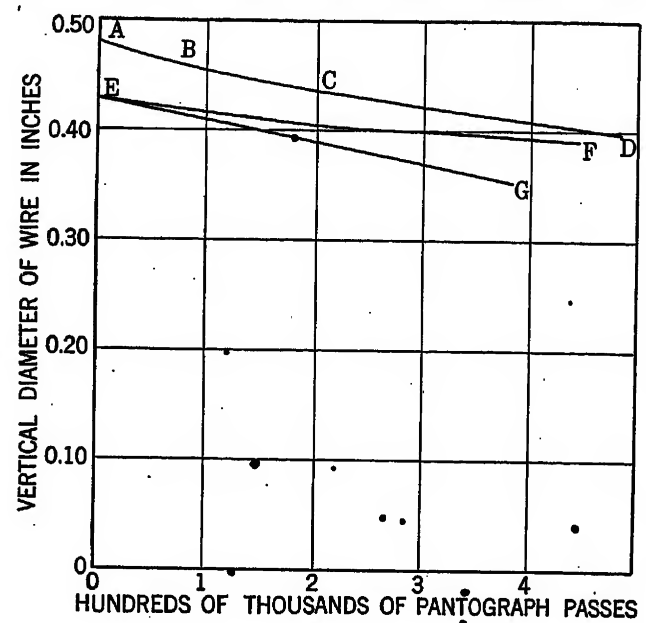

FIG. 1

A–B = 4–0 on C. M. St. P. & P. R. R.
A–C = 4–0 on I. C. R. R.
A–D = 4–0 on N. Y. N. H. & H. R. R.
E–F = 3–0 on I. C. R. R.
E–G = 3–0 on Pennsylvania R. R.

excess wear at the point where the pantograph resumes contact with the wire. The net effect may be said to be the sum of the effects of a change in gradient of the contact wire and the arcing caused by sleet. The wear due to this cause will probably be noticed most in the winter time when the roadbed is frozen and is difficult to resurface, particularly as at this season the pantographs are required to handle an additional electrical load due to the heater current being drawn.

The experience of the New Haven has been that generally the higher the speed of the train, the less the wear of the contact wire. This is borne out by the experience of the Illinois Central in a territory where four tracks carry high-speed express and special trains and two tracks relatively low-speed local trains.

The effect on contact wire wear of the amount of current collected is not so well known. The general impression is that as far as the effect of current alone

is concerned, the greater the amount of current, the greater the wear. Actually, it is difficult to determine the facts from experience because of the obscuring effects of other factors.

In the curves shown in Fig. 1 are given the relations between the vertical diameter of the contact wire and the number of pantograph passes. The curve for the New Haven takes into account all measurements made; that for the Milwaukee those measurements which represent maximum wear on the main line; that for the Pennsylvania only those measurements at places most susceptible to wear; and those for the Illinois Central all measurements.

In conclusion, then, for the purpose of minimizing contact wire wear it is necessary that the contact wire system be flexible, have little or no concentrated weight, and have gradual transitions from one height to another; that the pantographs be light, free moving, and actuated by sufficient pressure to insure good contact with the wire; that the question of lubricating pantographs be decided after considering such other factors as the presence or absence near the wire of abrasives which might adhere to the lubricating film; and that the condition of the roadbed be taken into consideration. Ice on the wires is abrasive and difficult to combat successfully. The speeds of trains and amounts of current collected are variables at best and probably do not affect the rate of wear appreciably.

Induction Motor Operation With Non-Sinusoidal Impressed Voltages

BY L. A. DOGGETT[1] and E. R. QUEER[1]
Member, A. I. E. E. Non-member

Synopsis.—The usual procedure in considering the operation of induction motors has been to neglect the effect of harmonics. Although in most instances this gives results which are sufficiently accurate, the question of how much these effects are or how much is being neglected has yet to be answered in electrical engineering literature. In this paper an attempt is made to answer this question. It is also devoted largely to a statement of results with only such explanation as space permits. The conclusions are that, with harmonics of 10 per cent or less, the harmonics produce an insignificant effect, for all types of induction motors and for all conditions of operation, except for the no-load condition. In this case, significant but not serious increases of I^2X occur. Also lightly loaded induction motors may be counted on to smooth out the impressed electromotive force wave.

THERE are two types of harmonics that may be present in induction motor operation, (a) time harmonics introduced by the impressed e. m. f. and (b) space harmonics introduced by the counter e. m. f. of the motor. The object of study in this paper is the former type of harmonics.

In order to visualize what happens in the case where the impressed e. m. f. contains one harmonic, it is convenient to think of an induction motor as consisting of two motors identical with the motor under consideration, with shafts connected and drawing power, one from the fundamental e. m. f. source and the other from the harmonic e. m. f. source. The reactance of the harmonic motor will be n times that of the fundamental motor; where n is the order of the harmonic. The resistance of the harmonic motor as indicated by our tests will be greater than that of the fundamental motor, although not n times as great. One author[2] claims the resistance of the harmonic motor to be the same as that of the fundamental motor. When this pair of motors is operating under any ordinary load, the slip is close to zero per cent for the fundamental motor, while for the harmonic motor it is a very large per cent, 133 1/3 per cent for the third harmonic in the two-phase motor, 120 per cent for the fifth harmonic in the three-phase motor, and 85 5/7 per cent for the seventh harmonic in the three-phase motor. For example, if 1800 rev. per min. is synchronous speed for the two-phase fundamental motor, $3 \times 1800 =$ 5400 rev. per min. in the opposite direction is synchronous speed for the third-harmonic machine. The slip is therefore 7200 rev. per min. or $7200/5400 \times 100 =$ 133 1/3 per cent. In the case of the seventh harmonic and the three-phase motor, $7 \times 1800 = 12{,}600$ rev. per min. in the same direction as synchronous speed, and the slip is therefore $(12{,}600 - 1800) \times 100 \div 12{,}600 = 85\ 5/7$ per cent. When a pure sine wave is impressed on the motor, 100 per cent voltage is considered to be impressed on the motor of fundamental frequency and 0 per cent on the harmonic motor. When a non-sinusoidal voltage of 100 per cent effective value is impressed on the motor, if the harmonic be 25 per cent of the fundamental, the fundamental motor will have impressed on it a 97 per cent voltage. Considering a given effective voltage, this voltage can be produced either by 100 per cent fundamental and 0 harmonic or with $100 \div \sqrt{1 + H^2}$ per cent fundamental and $H \times 100 \div \sqrt{1 + H^2}$ per cent harmonic, where H is a fraction, 0.25 for ex-

1. Pennsylvania State College, State College, Pa.
2. Arnold, Vol. 5, Part I, p. 194, *Die Asynchronen Wechselstrommaschinen die Inductionmaschinen.*

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ample in the above cited case. Thus, $H \times 100 \div \sqrt{1 + H^2}$ per cent voltage will be impressed on the harmonic motor and $100 \div \sqrt{1 + H^2}$ per cent on the fundamental motor. With non-sinusoidal operation, the fundamental machine will receive a decreased voltage and function as an ordinary induction motor functions with decreased voltage. The harmonic machine operating with a large slip will take currents, active and reactive watts, practically the same as if its rotor were blocked. The harmonic motor acts more or less as a harmless parasite on the fundamental motor, neither helping nor hindering the operation of the fundamental motor to any considerable degree. Its braking effect is entirely negligible so long as the harmonics are kept below 10 per cent. Its main disadvantage is that it prevents the fundamental motor from getting its full 100 per cent voltage and that it absorbs from the line a moderate amount of active and reactive power for which it does no good in return.

Coming now to practical operating conditions; the outstanding fact is that with a 10 per cent harmonic, the largest harmonic allowable by the A. I. E. E. Standards Rules, the quantity $100 \div \sqrt{1 + H^2}$ becomes 99.5 per cent, only half of one per cent loss in voltage impressed on the fundamental motor. Therefore the fundamental motor will have no more than a one per cent decrease in torque and horsepower. With a 10 per cent harmonic, the active and reactive watts taken by the harmonic motor are a small percentage of the total active and reactive watts for all conditions of operation except light loads. The braking or accelerating torque of the harmonic motor is a small fraction of one per cent of the fundamental motor torque.

Analytical Treatment

As suggested in the introduction, it is helpful to replace the motor under consideration by two motors, shaft-connected, and each identical with the original motor. Each of these motors will have its own equivalent circuit and its proper impressed electromotive force. Solutions of these two circuits may then be made separately and the results combined. By applying this method the operation of any induction motor for any condition may be predicted. Such calculations were made by the authors for a number of motors and a variety of operating conditions. These calculations are tedious and space does not permit their reproduction here. The conclusions from these calculations are that so long as harmonics are kept below 10 per cent, the departure of the motor from normal performance is quite negligible except for light loads. The case of light load is treated in a later section.

In order to establish the validity of this method of calculation, a complete test was run on a small squirrel-cage motor for both sinusoidal and non-sinusoidal operation. Fig. 1 shows curves of horsepower, efficiency, power factor, current and slip plotted against torque. The constants of the motor follow:

Name plate data:

A 5-hp., three-phase, 60-cycle, 110-volt, 26½-ampere, 1150-rev. per min., squirrel-cage motor.

Blocked test data:

E per phase (WYE) = 14½ volts, I = 26½ amperes
R per phase (cold) = 0.227
X per phase = 0.492

Running light data:

E line = 50½ volts, $I = 2.86 - j\,3.14 = 4.22$

The tests were run at a voltage of 50½, sufficiently below rated voltage to allow the motor to be taken through its complete characteristics. To obtain these complete characteristics, the following arrangement of apparatus was used: A d-c. motor drove a harmonic alternator,[3] which supplied the induction motor under test. Shaft-connected to the induction motor was an electrodynamometer which pumped power to another

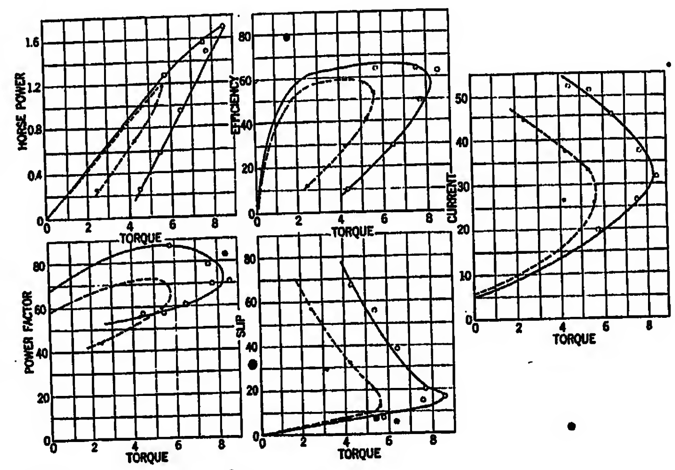

Fig. 1—Test Results of Motor Operated on Sinusoidal and Non-Sinusoidal Voltages

The full lines show operation on sinusoidal voltages; the dotted lines non-sinusoidal operation

d-c. machine driven by a synchronous motor. The harmonic alternator's speed was maintained at 1234 rev. per min. The actual percentage of the fifth harmonic impressed on the induction motor was measured by the "wave-shape meter"[3] and was found to be 57 per cent.

It was found also that when calculations were made using the equations for the accurate equivalent circuit of the induction motor, very good agreement was had in the case of the speed-torque and horsepower-torque curves and fair agreement for the other three curves. Since beyond the breakdown point the currents are excessive and the values of primary and secondary resistance are uncertain because of heating, only a moderate agreement between observed and calculated values was obtained. For those who might care to check these calculations, the following circuit constants are supplied: R_1 (hot) = 0.13; R_2 (hot) = 0.14; $X_1 = X_2 = 0.25$; $g_0 = 0.098$; $b_0 = 0.1076$, volts per phase

3. *A New Wave Shape Factor and Meter.* Doggett, Heim, and White, A. I. E. E. Trans., Vol. 45, 1926, pp. 435–442.

= 29.12. When operating with the 57 per cent fifth harmonic, the voltage of the fundamental reduces to 25.3 volts, while the fifth harmonic voltage becomes 14.4 volts.

While such calculations cannot be reproduced here, it may be desirable to give just two simple calculations as follows:

The maximum torque, fundamental test

$$= \frac{3 \times 2}{2\ \pi\ 61.7} (29.12)^2 \frac{1}{2\ (0.13 + \sqrt{0.13^2 + 0.5^2})} \times 0.737 = 7.5 \text{ lb-ft.}$$

The maximum torque, non-sinusoidal test

$$= 7.5 \times \left(\frac{25.3}{29.12} \right)^2 = 5.68 \text{ lb-ft.}$$

The above calculations are not based on the exact equivalent circuit and are only moderately close.

Although complete calculations have not been included, they provide the basis for the following discussion of the curves of Fig. 1.

Slip-Torque Curves. When the fifth harmonic is present, the fundamental must be reduced, in this case from 29.12 to 25.3 volts. As illustrated by the calculation, this reduces the torque in the ratio of the square of the voltages. The reduction due to the counter torque of the fifth harmonic is quite small, only about one-third of a pound-foot at breakdown. Neglecting this, it may be said that the motor acts as if operating simply with a reduced fundamental voltage.

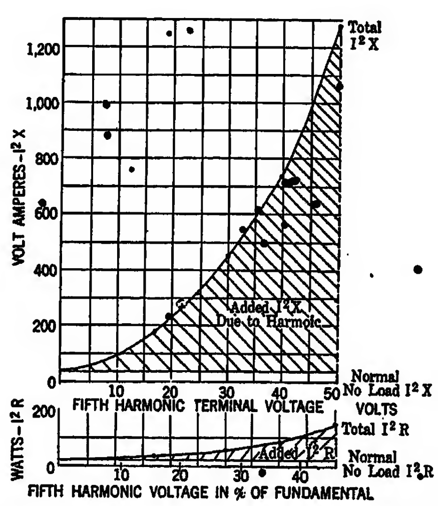

FIG. 2—TEST RESULTS AT LIGHT LOAD

Showing increase in $I^2\ R$ and $I^2\ X$ with increase in harmonic voltage

Horsepower-Torque Curves. These curves are corollary to the slip-torque curves, since

$$\text{hp.} = \frac{2\ \pi \text{ Torque } (1 - S)\ 1234}{33{,}000}$$

Current-Torque Curves. Up to breakdown for any assigned torque the current with non-sinusoidal operation must be larger than the current with sinusoidal operation for two reasons: (a) The reduction in fundamental voltage calls for a larger current to give the same torque. (b) The fifth-harmonic current must be compounded with the fundamental current according to the law

$$I_{total} = \sqrt{I_1^2 + I_5^2}$$

Efficiency-Torque Curves. For any assigned torque, the extra current will result in extra copper loss and therefore less efficiency.

Power-Factor-Torque Curves. For any assigned torque,

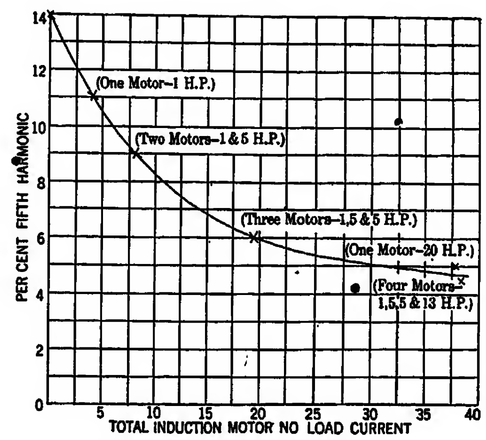

FIG. 3—CURVE SHOWING HOW HARMONIC VOLTAGE OF GENERATOR DECREASES WITH INCREASING INDUCTION-MOTOR LOAD

a very considerable $I^2\ X$, due to $I_5^2\ X_5$, will materially increase the demand for reactive power and thus reduce the power factor.

LIGHT-LOAD CONDITION

As has already been pointed out, an induction motor operating on light load with non-sinusoidal impressed voltages may be expected to show some considerable departure from normal operation. In general, the no-load copper loss, $I^2\ R$, and the no load $I^2\ X$ will be very much increased. Calculations show that an average three-phase motor acted upon by an e. m. f. containing an eight per cent fifth harmonic, if its percentage of reactance be as low as 10 per cent, will have its no-load copper loss multiplied by three, and its no-load $I^2\ X$ multiplied by seven. In a certain rather high-reactance motor, the normal no-load $I^2\ R$ was 49 and the normal no-load $I^2\ X$ was 119. Due to a 10 per cent fifth harmonic, the added $I^2\ R$ was 33 and the added $I^2\ X$ was 60. Repeated attempts to measure this added loss accurately proved failures, and the following test is submitted to illustrate the above claims without trying to cite an individual case of exact agreement between calculation and observation.

In this rather unusual test, the stator of a wound-rotor induction motor was connected to the fundamental terminals, while the rotor was connected to the fifth-harmonic terminals of a harmonic alternator.[3] On the stator was impressed normal voltage and normal frequency continuously, while the fifth-harmonic voltage

was varied from zero to 50 volts. Although tests with both directions of phase rotation of the fifth harmonic were made, the fifth-harmonic current and power data were alike in the two cases. From this test and two supplementary blocked-rotor tests, sufficent data were obtained to plot the curves of Fig. 2, which show the $I^2 R$ and $I^2 X$ plotted as a function of the per cent harmonic. In this case, a 20 per cent fifth harmonic doubles the no-load $I^2 R$ and multiplies the no-load $I^2 X$ by seven.

Although at no-load the added $I^2 X$ appears quite significant, it usually is small in comparison with the reactive power needed for the excitation of the motor. In this case, the excitation required some 1350 volt-amperes.

An induction motor supplied with non-sinusoidal e. m. fs. will take from the line some additional $I^2 X$ and $I^2 R$. It will draw from the alternator harmonics of current which by internal drops will reduce the sources of non-sinusoidal e. m. fs. inherent in the alternator. Any alternator has a poorer regulation at frequencies higher than normal. To all but the fundamental frequency, the running induction motor acts practically as if blocked, *i. e.*, slip in the neighborhood of one. Therefore, for harmonics like the fifth and seventh, the induction motor at no-load will have a lower impedance than it has for the fundamental. In such a case, the current per volt will be larger for the harmonic than for the fundamental and with a sufficiently large harmonic e. m. f. present, the harmonic current may exceed the fundamental current. The alternator, however, has a poor regulation when operated on a harmonic. Consequently, an alternator which shows a 14 per cent fifth harmonic at no-load will show a less per cent harmonic, (that is, 5 per cent), when operating unloaded induction motors, and this is illustrated by Fig. 3. In short, induction motors have some tendency to smooth out the e. m. f. wave of the alternator which is supplying them. The results of this test were obtained by use of the wave-shape meter.

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Research

ANNUAL REPORT OF COMMITTEE ON RESEARCH*

To the Board Directors:

It is now generally recognized that progress in science and industry depends largely on research. Electrical engineering in particular must trace practically all its advances to some form of research, whether it be pure or applied. Accordingly a complete report on research in this art must necessarily involve practically all the developments in its various branches such as communication, machinery, transmission, etc. Inasmuch as this is particularly material for the Institute committees involving these branches, an attempt is made in this report merely to mention the various research bodies and their work in general, and to list briefly the outstanding achievements in engineering and physical research during the past year.

Considerable assistance was received from various members of the Research Committee in the preparation of this report, particularly Messrs. V. Bush, S. M. Kintner, M. G. Lloyd, D. W. Roper, C. E. Skinner, R. W. Sorensen, and J. B. Whitehead. Several non-members provided valuable contributions, particularly Doctor W. F. G. Swann of the Bartol Foundation.

Research Organizations

The National Research Council has been very active in sponsoring research and its committee on Electrical Insulation has started an extensive program. At a two-day symposium conducted in Baltimore last fall by this committee, papers were presented reporting the results of studies of the mechanism of cable deterioration, the products of the breakdown of liquid dielectrics, the current wave form in dielectrics under high stress, the influence of air and moisture in impregnated paper insulation, short time absorption curves in composite insulation, the relation of dielectric absorption and dielectric loss, anomalous conduction in liquid insulation, gaseous ionization in cables, and the breakdown of solid dielectrics. At a second symposium, conducted during the Washington meeting of the American Physical Society, papers were presented on the mechanical and electrical strength of dielectric crystals, electrical convection in oil, effect of temperature, pressure and frequency on rubber, influence of surface and space charges on the apparent conductivity of dielectrics, electron bombardment of hydrocarbons, and the dependence of dielectric polarization upon molecular condition.

The Bartol Research Foundation of the Franklin

*COMMITTEE ON RESEARCH:

F. W. Peek, Chairman,

H. D. Arnold,	J. A. Johnson,	D. W. Roper,
Edward Bennett,	V. Karapetoff,	Clayton H. Sharp,
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W. F. Davidson,	M. G. Lloyd,	T. S. Taylor,
W. P. Dobson,	Chester W. Rice,	J. B. Whitehead.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Printed complete herein.

Institute under Doctor Swann carried out a valuable research program during the past year. Among the important subjects investigated were the following: phenomena in the electric arc, reflection of atoms on crystals, excitation of atoms by electron impact, possible influence of cosmic rays on radioactivity, production of X-rays by protons, influence of a-c. fields on light transmission through water, corpuscular radiations of cosmic origin, energy lost by electrons passing through thin foils, polarization of light produced by impact of cadmium atoms with excited mercury atoms, photoelectric effect in thin films of potassium and sodium, and absorption of cosmic radiation in air. A number of theoretical problems was considered mathematically such as the scattering of electrons by atoms, theory of Compton effect produced by standing electromagnetic waves, possibility of detecting individual cosmic rays, relation between mass and energy, and ionization by an electron traveling with speed comparable with that of light.

Several noteworthy research accomplishments were made at the Bureau of Standards during the past year. The corona voltmeter was investigated, and a careful study made of the effects of pressure, temperature, and humidity on its accuracy. A redetermination of the absolute value of the international ohm was carried out. Important work was done toward developing a suitable radio beacon for aircraft. An electrical seismometer also was devised which is proving to be a very satisfactory instrument for recording earth movements.

Electrical Engineering Research in the Colleges

During the past year an a-c. calculating board was developed at the Massachusetts Institute of Technology for representing in miniature almost any power system. The device offers a practical means of solving easily the steady-state problems of current and power division, system voltage, load balance, power factor adjustment, and the transient problems of both symmetrical and unsymmetrical short circuits with attendant considerations of system stability.

Important investigations in the colleges are being made of solid and liquid insulations, particularly as they relate to underground cables. Under the auspices of the National Electric Light Association, the Association of Edison Illuminating Companies, and the American Institute of Electrical Engineers, a study of thermal characteristics and methods of measurement is being made at Massachusetts Institute of Technology, the effect of residual air and moisture at the Johns Hopkins University, and ionization characteristics at Harvard University.

Under the Utilities Research Commission (consisting of representatives of the Samuel Insull utilities) studies of methods of detecting cable failures and of physical properties of lead sheaths are being made at the University of Illinois, at Johns Hopkins University of the properties of impregnated paper, and at the University of Chicago of the fundamental significance of dielectric strength.

A large part of the research sponsored by the National Research Council and the Engineering Foundation is being conducted in the college laboratories, particularly in the East and Middle West.

Several of the college engineering laboratories on the Pacific Coast have been active in research problems during the past year. Some of the accomplishments of note were the study and analysis of Lichtenberg figures at the University of Washington; the X-ray studies at the California Institute of Technology, using the million-volt transformer set for tube excitation; and the investigation and measurement of high-voltage flashovers at Stanford University, where 60-cycle flashovers of gaps up to 36 ft. were made, the longest yet accomplished at commercial frequencies.

Outstanding Research Accomplishments in Electrical Engineering

Considerable progress was made during the past year in the study of lightning on transmission lines. Much of this was made possible through the adaptation of the cathode ray oscillograph for direct recording on power lines. Lightning waves recorded in lines have been duplicated in the laboratory and their effects on transmission lines, insulators, insulation, transformers and protective apparatus studied at will. For making these laboratory tests a lightning generator producing 5,000,000 volts was constructed. Smaller portable lightning generators were also produced and used for putting surges at desired points on lines.

By means of surge voltage recorders and klydonographs, distributed at intervals on several power systems, valuable data also were obtained on the crest values, polarity, attenuation, and frequency of lightning surges on lines.

As a result of lightning research, it is now possible to design transmission lines, and to coordinate the line and apparatus insulation so as to have power systems which are highly resistant to lightning.

A well coordinated program in lightning research is being continued. A considerable part of the field work is being done on transmission lines in cooperation with operating engineers.

A number of advances was made in transformer design last year. Among these was the development of the non-resonating transformer. The object of this type is to cause a uniform voltage distribution throughout the windings under all frequencies and lightning surges.

Several improvements were made in switches and circuit breakers during the past year. One achievement in this line was the development of the Deion circuit-breaker switch. In its primary application to practise it has been designed for use up to 15,000 volts, its operation making use of a series of extremely short gaps in air.

In the field of electrical machinery numerous ad-

vances were made. Noteworthy among these was the successful development and operation of a 10,000-kw. mercury turbine, whose efficiency exceeded the previously predicted values. The popularity of the high pressure turbine also increased as may be witnessed by the fact that five new 1200-lb. units were designed during 1928. The development of hydrogen-cooling for reducing losses and increasing the capacities of generators and synchronous condensers made appreciable strides. Units up to 20,000 kv-a. using this method of cooling were built during the past year. The tendency to use higher generated voltages with large capacity units for certain classes of service continued. Several 22,000-volt generators were designed and installed in this country, and one 33,000-volt unit was placed in operation in England, connection being made directly to an underground cable system with no intervening transformer.

Aviation profited appreciably from research developments carried out last year in the Bureau of Standards and in the laboratories of the several larger industrial concerns. The principal advances consisted of additional navigational aids for commercial aviation. Here radio contributed principally in improving communication, course navigation and fog landing. Better facilities for navigation and landing in the fog were added by the development of neon light beacons and markers. A method of depth-sounding in the air to enable aviators to determine their altitude was devised. The procedure consists in sending out radio waves from the airplane, which are reflected from the ground and received again by the plane. A magneto compass also was designed, weighing less than one-fifth of the present earth-inductor compass. A means of accurately measuring the amount of gasoline was devised making use of electrical impulses transmitted from diaphragms located in the airplane tanks.

Much work was carried out during the year in perfecting and applying photoelectric devices to many uses, such as smoke detection and measurement, control of illumination, operation of traffic devices, etc.

Marked progress was made on the question of television and far greater use will undoubtedly be made of it in the near future. Appreciable advances were made in the speed and convenience of picture transmission, by both wire and wireless, during the year.

The great increase in popularity of the talking moving pictures furnished added stimulus to research in that line so that considerable improvement is expected in this art.

Decided progress was made in metallurgical work through the wider application of inductive heating, both in furnaces of the vacuum type and the non-vacuum type.

The increasing temperatures, pressures, and speeds of electrical machinery have made it necessary to give added study to the characteristics of metals under high temperatures and mechanical stresses. Results of great value have been reported.

Research in magnetic materials and magnetic phenomena was continued, and much was added to our understanding of these vital subjects.

Laboratory devices for the analysis of noise were developed and studies made of the sources of noise in machinery, and its elimination.

Outstanding Research Accomplishments in Physics

Light and Spectroscopy. Michelson, Pease, and Pearson, University of Chicago and Mount Wilson Observatory, have repeated the Michelson-Morley experiment and find no shift that can be interpreted as arising from an ether drift. This completely agrees with the original results obtained by Michelson and Morley and also seems to add strength to the relativity theory which was developed to explain the earlier experiments. (*Trans. Optical Soc.*)

The Indian Physicist, Raman, has shown that light scattered from many substances contains not only the original frequencies of the incident light, but also the other frequencies differing from it by the natural frequencies of the scattering substance. This effect has been used by Raman and others to study the natural frequencies of many substances as well as to extend further the laws of scattering.

Our knowledge of the structure of many diatomic molecules has been materially extended by the analysis of their band spectra by Mulliken and others.

McLennan and his students have continued their studies of the Aurora and have definitely fixed the position of the unknown auroral lines in the structure of the oxygen atom. (*Proc. Royal Soc.*)

Study of the band spectrum of oxygen by Babcock and Dieke of the Mount Wilson Observatory and Giauque and Johnson of the University of California have shown the presence of an isotope of atomic weight 18. This heavier isotope is about one two-thousandth as plentiful as the isotope 16 so its presence had not been detected by mass spectrograph methods. (*Nature*, March 2, 1929.)

Bowen, California Institute of Technology, has shown the presence of sulphur in the nebulae, by the identification of some more unidentified lines of the spectrum. (*Nature*, March 23, 1929.)

J. W. DuMond of California Institute of Technology has developed an experimental method based on the study of the spectral distribution of Compton modified radiation for determining the velocity distribution of both bound and conduction electrons in metals and of electrons in non-metals. (*Physical Rev.*, May, 1929.)

Absolute measurements of X-ray wavelengths have been made by means of an optical grating. By this means it is possible to get an independent determination of the charge on the electron.

Conductivity. Bridgman, of Harvard, continued the

experiments on conductivity and thermoelectric effects in anisotropic single-crystals of metal and showed that the electronic effects in metals follow the crystal-symmetry. (*Nat. Academy of Science*, Vol. 14, p. 943, December, 1928.)

Kapitza has made further experiments on variations of resistance of metals in very strong magnetic fields up to 300,000 gauss. Bismuth lost its conductivity. These experiments may explain much about the conductivity of electricity in metals. (*Proc. Royal Soc.*, Vol. 123, p. 292.)

J. B. Johnson of the Bell Telephone Laboratories has been able to detect and measure the random motions of the electrons in a wire due to their temperature energy. From these measurements it is possible to determine the value of Boltzmann's gas constant. These results lend considerable support to the idea that the conduction electrons in a metal follow the laws of an electron gas. (*Physical Rev.*, Vol. 32, 1928.)

Electronic Emission. R. A. Millikan and C. C. Lauritsen, California Institute of Technology, constructed an apparatus, in which electrons were pulled from the electrodes by strong electric fields. The electrons so extracted were of such high velocities as to be capable of producing X-rays with wavelengths comparable to cosmic radiation.

DuBridge gave the first reliable evidence that the photoelectric threshold has exactly the same values as the thermionic work-function for the same metal. (*Physical Rev.*, Vol. 32, p. 961.)

Cardwell showed qualitatively a change of the photoelectric and thermionic emission at the change of an allotropic modification of the cathode.

A. Goetz, California Institute of Technology, gave the experimental evidence that the photoelectric emission and the threshold changes at the melting point and transition point of tin are such that the larger the atomic distance in the cathode the smaller the work function of of the metal. This shows that the mechanisms of the photoelectric and thermionic effects are of the same nature. (*Physical Rev.*, Vol. 33, March, 1928, p. 373.)

Lukirsky and Prilezaev succeeded for the first time in measuring the loss of energy of photoelectrons crossing the cathode towards the surface, thus showng that the photoelectric effect is not a pure surface effect, as has been generally considered.

Work in Theoretical Physics. The so-called "principle of uncertainty" stated by Heisenberg has gained general recognition as a fundamental principle of physics. According to this principle, it is impossible to determine at the same time the position and velocity of a particle with absolute accuracy. The product of the uncertainty in position and the uncertainty in velocity can never be less than Planck's constant h. This is because the method of observation itself affects the quantities to be measured.

The fundamentals of quantum mechanics have remained essentially unchanged, but many applications have been made. Heisenberg has given a striking theory of ferromagnetism based on the magnetic electron as the effective magnetic unit. The electrical resistance of a metal has been explained as due to the diffraction of the electron waves by the crystal lattice. Many of the other electrical properties of metals seem to find a satisfactory explanation on this basis. Neumann and Wigner have shown that all of the known qualitative rules for the analysis of spectra can be derived directly from the Schroedinger equation, and it has been possible to derive some quantitative relationships between spectral terms for spectra more complex than hydrogen. Rubinowicz has shown how the intensities of forbidden transitions may be predicted, so that from the appearance of such lines in the nebulae the physical state of the material may be inferred. Sommerfeld has applied the quantum mechanics to explain the observed distribution of photo-electrons ejected from gases.

The theory of relativity has received an important contribution from Einstein who has been able to give a unified treatment of the gravitational equation and the electromagnetic equations.

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ENGINEERING SOCIETIES EMPLOYMENT SERVICE

EXCERPTS FROM LETTERS OF APPRECIATION

June 17, 1929.

I think you have the finest service of its kind in the country and this despite the fact that several of them have been going for years before you started. I want to thank you most heartily for your interest in me.

June 20, 1929.

I wish to thank you for the courteous treatment which I have received at your hands and wish to assure you that I am more than satisfied with your service.

April 25, 1928.

Enclosed you will find my check for $90.00 (ninety dollars) corresponding to 1½ per cent of my salary. I consider this a very good investment, and wish to thank you for the help you have given me in obtaining this position.

November 5, 1928.

I am sure that some valuable results will come from the effort which you are making in our behalf and I also believe that if the right man is found through your Service, we can feel that we have turned over to you a position worthy of one of the Engineering Society members.

Abridgment of

The Electrical Engineering of Sound Picture Systems

BY K. F. MORGAN[1]
Associate, A. I. E. E.

and

T. E. SHEA[2]
Associate, A. I. E. E.

Synopsis.—The paper describes the technique and apparatus of sound picture recording and reproduction, with emphasis on their electrical engineering aspects.

The various steps in the processes of disk and film recording as they take place in the Western Electric systems are outlined. Microphone placements, sound insulation, monitoring and mixing, and the circuits for amplifying currents and distributing them to recording machines are discussed. This is followed by a description of the disk and film recording machines.

The changes which have been required in theater equipment to provide for the reproduction and projection of sound in synchronism with motion pictures are outlined.

Some of the laboratory developments and studies out of which recording and reproduction methods have grown are given brief mention.

* * * * *

That the development of sound recording and reproduction should be closely related to that of the telephone is only natural since many of the fundamental principles are similar. In that which follows the authors will have in mind principally the Western Electric systems of recording and reproduction.

Sound Picture Recording

The electrical recording of sound requires a method of transforming sound vibrations into electric currents; then the transmission, control, and amplification of these currents, and finally, a method of changing the electrical energy into mechanical energy in order that a permanent record may be had on the recording medium either by modulated light on a sensitized film or the movement of a cutting stylus in soft wax.

The essential parts of a studio recording system consist of microphone pick-ups on the stage, a mixer and volume control in the monitor room, system and monitor amplifiers, recording machines, and a synchronous motor system for synchronizing the recorders with the cameras.

The recording stages are constructed in such a manner that external noises may be excluded. The walls and ceiling are usually covered with sound absorbing materials.

The microphone, or microphones, must be placed in such positions as to pick up satisfactorily the speech or music occurring on the set. Often the location of the microphone is complicated by the construction of the set, and by the necessity of keeping it out of the field of view of the camera. The microphone may be mounted on a floor stand, hung from the ceiling, or suspended from the end of a long boom. The type of microphone used is the condenser transmitter. It is essentially a condenser in which one of the plates is a very thin, stretched sheet of duralumin, which may be set in vibration by sound waves. Thereby, the capacity of the microphone is varied and an electromotive force is set up in the electrical circuit to which the microphone is connected.

Various kinds of materials are used in the construction of sets, although the general tendency is to use those materials which are sound absorbing. The sets may have two or three walls, very seldom being completely closed.

In order to eliminate camera and motor noise, camera booths constructed of sound proof material with a clear glass window in front for the camera to "shoot" through have been used.

The monitor man is responsible for the balance, quality, and volume of the recording. It is his duty to be thoroughly familiar with the action being photographed and the acoustic conditions of the set, and to properly locate the microphones. He sits in a bay window in the monitor room with a clear view of the stage. Sounds are heard from the stage by means of monitor horns only, since the monitor room is insulated from the stage by sound proof walls. The monitor room simulates theater reverberation conditions, thus assisting the monitor man in obtaining the best recording results from the theater patrons' "auditory viewpoint."

The mixer table is the centralized control of the system. Controls are located here for fading in and out microphones, maintaining the volume balance between several microphones, and regulating over-all volume; also for operating communication systems, signal lights, and relay control switches. The volume indicator provides a visual method for the monitor man to keep the sound volume range within the limits of the recording system.

The microphone junction box which permits the interconnection of different microphones is located on the stage. The microphone circuits enter the mixer on the control platform where the mixing operation is performed and amplification obtained before trunk-

1. Electrical Research Products, Inc., Los Angeles, Calif.
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ing to the recording building. In the recording building, which is usually separated from the stages because of the fire hazard, is concentrated all the recording, power, and auxiliary equipment except that mentioned above. In this building are located the wax shaving room, battery room, motor-generator room, "dubbing"[3] room, film loading room, recording rooms, test laboratory, and amplifier room.

The amplifier room contains the system amplifiers, monitor amplifiers, and power control panels for all the channels.

Bridging amplifiers divide the electrical circuit four ways. The bridging amplifier outputs are connected to the wax and film recording machines in the recording room. If the picture is to be released with the sound recorded on film, it is common practise to operate two film recording machines for the permanent film record and one wax recorder for playback purposes.

Monitoring is accomplished in two ways,—direct and indirect. The direct monitor circuit originates at the bridging bus and is connected to the horns in the monitor room. The indirect monitoring is done by means of a photoelectric cell located in back of the film and in line with the modulated light beam striking the film from the front. A small amount of modulated light is transmitted through the film and reaches this photoelectric cell.

The recording rooms usually contain two film recording and two disk recording machines. These machines

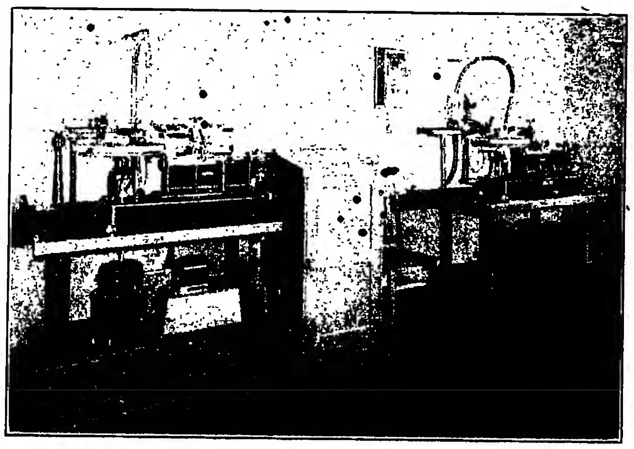

Fig. 13—Wax Recording Machines

are associated with one recording channel. They are all driven in synchronism with the camera motors on the stage.

The wax recording machine, used in the Western Electric system of disk recording, (Fig. 13.) consists of the following parts: a motor drive, a reduction gear with a belt drive connected to the lead screw, which moves a recorder radially across the surface of the wax disk, and a second reduction gear driving a turn-table on which the wax is placed.

The recording is made with an electrical recorder which receives its power from the system amplifiers. The electrical energy drives a recording stylus, made of sapphire or ruby, which must be sharp and of a shape to insure a clean cut, since any roughness in the walls of the groove introduces extraneous noise in the reproduced sound. The records used in the Western Electric system are lateral cut records, in which the

Fig. 14—Film Recording Machines

grooves are of constant depth and oscillate about a smooth spiral.

After a record has been cut, two procedures may be followed, the record may be processed for use in theaters, or the sound may be reproduced directly from the wax records by means of a "playback" reproducer. The use of the wax playback has proved advantageous to the director and actors in immediately judging the dramatic effect and the quality of a recorded scene without the necessity of waiting for the film or wax record to be processed.

The film recorder (Fig. 14) and its driving motors are usually mounted on a concrete slab insulated from the building structure by means of cork mats to prevent the transmission of excessive vibrations to the recording machine.

The machine contains a mechanical damped film drive mechanism, and by means of a lamp, lens assembly, and light valve, records sound on the film.

The light valve[5] is an electromechanical shutter actuated by amplified sound currents. It modulates a light beam of constant intensity which is projected by means of the lens system on to the film, thus producing a film record of variable density.

The interlocking[6] of the motor system employs a

3. "Dubbing" signifies a copying or combining process effected through re-recording.

5. For a more detailed discussion, see "Sound Recording with the Light Valve," D. MacKenzie, *Bell System Tech. Jl.*, January, 1929.

6. For a complete discussion of the synchronizing and regulating methods used, see "Synchronization and Speed Control of Synchronized Pictures," H. M. Stoller, *Bell System Tech. Jl.*, January, 1929.

principle known for many years in the electrical power field. It consists of connecting the stators and wire wound rotors of polyphase slip ring induction motors with similar electrical impedance characteristics, in parallel, and the placing of an alternating voltage across the stator. Hence, if the rotor on the distributor

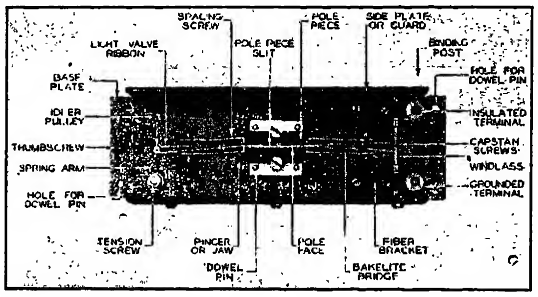

Fig. 15—Light Valve

is driven at a constant speed, all interlocked motors are likewise driven at the same speed independently of the power supply frequency and the actual number of revolutions from start to stop is exactly the same for all motors.

Sound Picture Reproduction[7]

The introduction of sound into the motion picture theater has also necessitated changes. It has been necessary to redesign and rebuild the projection booths to take care of the special sound reproducing equipment.

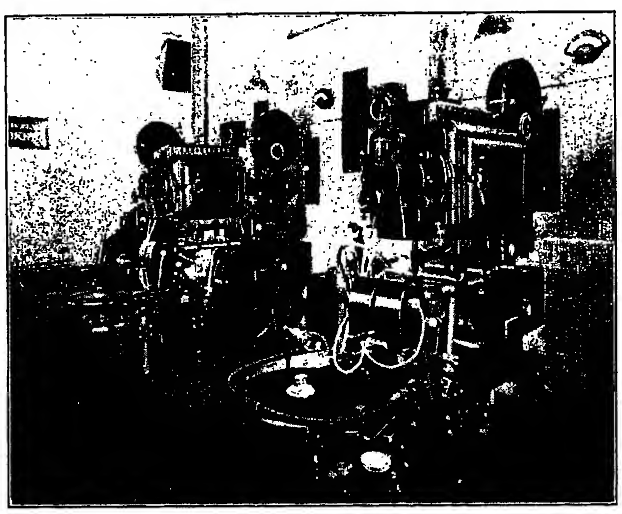

Fig. 20—Projection Booth, Showing Universal Picture Projection and Sound Reproducing Machines

Towers have been built to support the horns behind the screen. In some instances theaters have been treated acoustically in order to improve the reproduction.

7. The sound reproduction system used in theaters will be discussed only briefly, on account of the rather complete description given by E. O. Scriven in *Bell System Tech. Jl.*, January, 1929, "A Sound Projector System for use in Motion Picture Theaters."

A typical installation layout for talking motion pictures consists of: (1) film and disk reproducing attachments, by means of which small electric currents are generated with variations corresponding to the sound waves produced in recording, (2) vacuum tube amplifiers which greatly magnify these electric currents, and (3) sound projectors consisting of receivers and horns which convert this electric energy into sound.

Sound film is run through a standard projector modified by the addition of the sound reproducing attachment.

A light beam of high intensity is concentrated by an optical system containing a slit and focused to a fine line across the sound track of the film which passes through the sound gate. The film at this point moves with a uniform recording speed of 90 ft. per minute. On the film the sound record consists of a narrow margin (the sound track of Fig. 21).

The spacing of the light and dark bands along this track determines the pitch of the sound, while the varying density determines the quality and the loudness.

Fig. 21—Picture and Sound on Same Film—Variable Density Method

On the other side of the sound gate and back of the film is a photoelectric cell which produces a small electric current with variations corresponding to the modulated light which strikes it. The photoelectric cell output is strengthened by a small amplifier built into the sound attachment and then carried to a fader which is used to control the sound volume during the showing of the film. From the fader the current is carried to an amplifier of size and power suitable for the theater. The output of this amplifier passes through a distributor panel to the loud speakers and horns located behind the screen from which the sound issues in synchronism with the picture.

In the disk method of reproduction a current is generated by an electric reproducer playing on a disk record. The record is much larger than an ordinary phonograph record and revolves at 33⅓ rev. per min., thus enabling each record to play throughout a whole reel. The small electric current from the reproducer is carried to the fader where control is effected and thence to the amplifier and loud speaker system as in the film method.

By using two projectors alternately, a continuous program can be run as with silent picture projection.

This is accomplished by using the fader as a sound control at the same time that the changeover is made from one reel to the next, so that with proper operation the audience is unaware of any change being made. Unlike silent motion picture projection where the film is generally projected at a faster speed than it was photographed, the sound picture must be shown at exactly the same speed at which it was made. A constant speed is maintained by means of a special type of motor and a vacuum tube controlled electrical governing system similar to the distributor controlled system used in recording.

Dependence of Sound Pictures on Other Electrical Engineering Developments

The general processes involved in disk and film recording and reproduction have been discussed. From studio microphones to theater loud speakers the dependence of this new technique upon other electrical engineering developments has been heavy.

We need but to survey the series of steps involved in the processes of recording and reproduction to see these relationships. Let us consider a few of the types of apparatus employed:

1. *Microphones, or Condenser Transmitters.* The condenser transmitter was developed originally in connection with studies of high quality telephonic speech. Originated by E. C. Wente,[8] the condenser transmitter comprised a substantial step beyond the earlier carbon microphones.

2. *The Light Valve.* The light valve, also developed by Mr. Wente, has been adapted from the light valve used regularly in the commercial transmission of pictures over telephone lines.[9]

3. *Amplifiers.* The use of amplifiers for telephone, radio, public address, and other purposes is too well known to require much emphasis here. In sound picture recording, the currents derived from the condenser transmitters are so weak in comparison with those required to actuate a recording stylus or a light valve that amplification is vital.

For purposes of illustration, and as rough average figures, at a moment when the power of normal speech is about 10 microwatts, the power used to operate film and disk recorders would correspond to 0.006 and 0.018 watts, respectively; the power delivered by loud speakers in a large theater, however, would for the same conditions be about two watts.

4. *Loud Speakers.* As in the case of amplifiers, loud speakers have already been widely used in telephony, radio broadcast reception, and public address reinforcement. While there are various types of loudspeakers available, the horn type has been adopted in Western Electric systems chiefly because of its high efficiency and large power-handling capacity, consistent with high quality reproduction.

In addition to these types of apparatus, there have been special incandescent lamps developed as light sources for the recording and reproducing systems, photoelectric cells have been employed in improved form, special motor systems have been used for synchronizing, regulated reproducer motors have combined vacuum tube technique with special motor design, monitoring circuit arrangements have been adapted from communication systems, signaling circuits have been suited to sound recording needs, mixing apparatus has grown out of that used for combining the output of public address and radio broadcasting microphones, and electrical test sets of various kinds have been designed for special purposes.

Extensive studies of the relative importance of different frequencies in speech from an intelligibility standpoint have been essential to the attainment of high quality transmission. Likewise, measurements of the relative distribution of energy in speech and music have been important in estimating load-carrying capacities of apparatus and the magnitudes of interference currents between circuits. Again, studies of the influence of various amounts of noise on the audition of speech and music have furnished design requirements on *quietness* in apparatus and circuits. In this connection, it should be noted that in the use of commercial communication circuits, there is a continuous effort to reduce the interference to signal transmission from extraneous noises.

With regard to circuits for transmitting frequency ranges, an extensive and well-developed art has grown up in communication engineering which has been effectively applied to sound picture work. Examples of contributions from this source are (1) the method of comparing sound intensities by the use of power levels based on transmission units called *decibels,* (2) the method of *matching impedances* which secures optimum transmission, (3) the use of *gains* in amplifiers and *transmission losses* in mixing and other networks, (4) the method of avoiding resonances by annulling reactance effects over wide frequency ranges, (5) the method of designing high frequency electrostatic shielding arrangements on a network basis, and (6) the correlation of mechanical, electrical, and magnetic vibrations by means of circuit analogs.

Other studies worthy of reference are those on magnetic materials (for example, *permalloy* used in transformers) and non-magnetic materials (for example, *duralumin* used in condenser transmitters and light valves), and studies of room acoustics and the properties of acoustic absorbing materials.

General

In the days of the silent photoplay it was often the practise to schedule a feature almost before the story was written. During the actual photographing of the pic-

8. See "Electrostatic Transmitter," E. C. Wente, *Phys. Rev.,* May 1922, pp. 498-503.

9. See "The Transmission of Pictures over Telephone Lines," Ives, Horton, Parker, Clark, *Bell System Tech. Jl.,* April, 1925, pp. 187-214.

ture many thousands of feet of film were "shot" at random on large scenes in order to be sure that enough material would be available for the film cutters and editors to patch into a good story. Actors were directed so that the memorizing of lines was not important. With sound it has been necessary to thoroughly plan and rehearse each scene beforehand. Actors must memorize their lines and directors remain silent during the recording.

The director must broaden his artistic and dramatic efforts to include the new technical branch. Sound engineers with more electrical engineering experience than motion picture experience have found it necessary to adjust themselves to the new environment. These two different types of personalities have joined forces. The future development of sound pictures is certain to be swift and far reaching. In this development the electrical engineer is certain to have an important place.

Abridgment of

Magnetic Shielding

(Shielding of Magnetic Instruments from Steady Stray Fields)

BY S. L. GOKHALE[1]

Member, A. I. E. E.

Synopsis.—This paper is a brief survey of the vast amount of work on magnetic shielding of instruments against steady stray fields and allied problems by several authors during the last fifty years. It contains first a simplified presentation of the method of zonal harmonic analysis by way of introduction to the mathematical theory of shielding as presented by those authors, and second, a brief summary of their theoretical inferences and experimental findings. In a paper of this kind no "conclusion" is necessary; the following table of contents explains the plan of presentation followed herein.

I. Introduction

The phenomenon of magnetic shielding is very important from the practical as well as from the theoretical point of view. In the past, a considerable amount of work has been done by way of developing a complete mathematical theory for each important case of shielding which occurs in laboratory or engineering practise. Several formulas have been evolved for practical use, and some of them have been verified by test. The mathematical treatment of the subject as presented by the several authors is not only somewhat difficult to follow, but it starts out from a point in higher mathematics, generally beyond the range of studies of the average technical student. Consequently, most of the work in the past has remained a sealed book to all except those who were compelled, and had the ability, to forge their way through that mathematical maze. The purpose of this paper is two-fold; first, to introduce the mathematical aspect of the problem in a simple form so as to bring the reader to the starting point of the classical work presented by authorities like Professor Rucker without having to go through the Laplacian equation and its solution as a necessary preparation, and second to summarize results of the mathematical study and of the experimental findings of the other physicists. It contains nothing new except the mode of presentation.

2. Designed and Incidental Shielding

For practical purposes the study of shielding may be divided into two divisions.

(a) Study of shield design

(b) Study of incidental shielding

The classification is important for practical purposes only, and has no foundation in theory. The purpose of the study (a) is to obtain a formula for the most efficient shield and is concerned with those cases wherein good shielding is essential; the study (b) is concerned with cases in which shielding occurs incidentally as a collateral phenomenon irrespective of desirability or unde-

Part 6 of a Symposium of six papers on Shielding in Electrical Measurements.

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Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

sirability of the effect. The same fundamental theory underlies both the above aspects of the study, but the conditions involved in the two problems call for different methods of approaching the solution; hence, the need of the above classification. The problem of designing a satisfactory shield for protection of galvanometers against external field belongs to the first class; the problem of computing magnetic forces on a conductor located in the slots or tunnels of the armature of a motor belongs to the second class. The solution of the first problem is best obtained by the use of harmonic analysis; the solution of the second, by the use of electromagnetic images (geometric). In anticipation of the following analysis, it may be noted at this point that the method of harmonic analysis is also fundamentally a method of magnetic images. (Section 6).

3. Problem of Shield Design

In the complete form of the paper this section is given over to a brief discussion of the above subject.

4. Theory of Shielding: Methods of Analysis

Theoretically, the action of a shield consists of a change of path of flux lines, due to refraction of those lines at the boundary surfaces of the shield caused by differences of permeability on the two sides of the boundary. This interpretation of the shielding process cannot be reduced to mathematical formulas except in an indirect way, in terms of some intermediate phenomenon, such as distribution of magnetism on the surfaces of the shield. Thus, there arise three practical

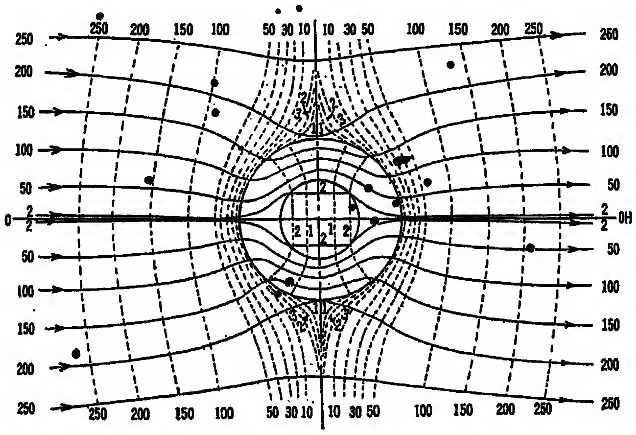

Fig. 1—Bending of Flux Lines by a Shield

methods of interpreting the action of the shield in mathematical terms:

1. The method of least reluctance
2. The method of images
3. The method of harmonic analysis

The first method lends itself easily to account for the action of the shield in a qualitative sense, but it is not convenient for quantitative work. The second and third methods are best suited for computation. The first method is based on the conception that lines of flux are refracted so as to follow the path of least reluctivity, and consequently that most of the flux lines follow the apparently longer but really the easier curved path through the walls of the shell instead of traversing the straight and shorter path through the space enclosed by the shield. This line of reasoning is very convenient for a classroom exposition but it fails to explain clearly the fact that some lines traverse the space enclosed by the shell instead of all lines going around the enclosure; nor does this conception explain the bending of the lines outside the shield where they

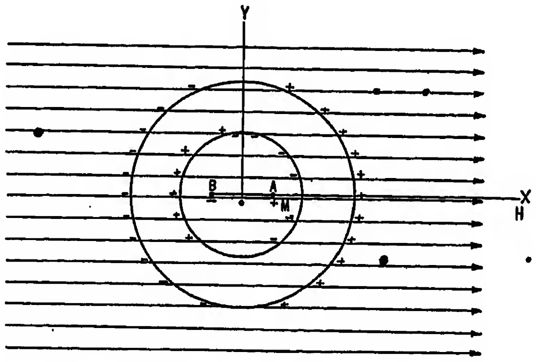

Fig. 2—Magnetic Poles on a Shield Due to Induction (Bending of Lines is Ignored in This Diagram)

approach the shield without touching it and follow a longer path of apparently greater reluctance without any compensating diminution of reluctance, by going a part of the way through the iron (see Fig. 1, line No. 200). It is possible to explain all these difficulties by taking fully into account the diminution of permeability by congestion of flux, the bending of the equipotential surfaces, and the broadening of the tubes of flux; but then the explanation is no longer simple and has no other compensating merit. The other two methods are based on the conception that the shells are themselves magnetized by the inductive action of the field (see Fig. 2) and become in turn a source of a second magnetic force which in the enclosed space is opposed to the original field. The value of the field in this space is the resultant of the original field and the opposing field produced by the shield. This method of interpretation is not very difficult to comprehend, and has the further merit of lending itself easily to mathematical analysis.

5. Method of Magnetic Images (Geometric)

A paragraph in the complete paper describes the above.

6. Harmonic Analysis: Conception of Harmonic Magnets and Harmonic Images

In the complete form of the paper this subject is discussed at some length.

7. Zonal Harmonics

This department of the complete paper includes a number of working equations and diagrammatic figures.

8. DuBois' Formula for Shield Factor

It is not possible in a brief paper of this kind to go through the complete analysis of the shield problem. The purpose of this paper is merely to introduce the subject for the benefit of those whose knowledge of harmonic analysis is limited to Fourier's Series. For a more complete study of the problems, see "Magnetic Shielding" by Esmarch (*Ann. der Physik.*, Vol. 39, 1912, p. 1553), and by Rucker (*Philosophical Mag.*, Vol. 37, 1894-95, p. 95).

From Rucker's general formula referred to above, DuBois[5] has derived the following formula for the case

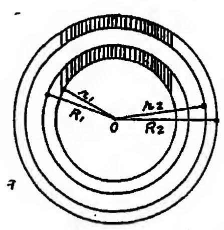

Fig. 5—Spherical Shield of Two Shells

of a spherical shield of two concentric shells, with a shell of non-magnetic material between, (Fig. 5).

$$g = 1 + \frac{2}{9}\,\frac{(\mu - 1)^2}{\mu}\left[(1 - p_1 p_2) + \left(\frac{2\mu^2 + 5\mu + 2}{9\mu}\right) m_1 m_2 m_{12}\right] \qquad (9)$$

where

$$\begin{aligned} p_1 &= r_1^3/R_1^3; & m_1 &= 1 - p_1 \\ p_2 &= r_2^3/R_2^3; & m_2 &= 1 - p_2 \\ p_{12} &= R_1^3/r_2^3; & m_{12} &= 1 - p_{12} \\ g &= H\,e/H\,i; \text{ (Equation (1-2))} \end{aligned}$$

Using the abbreviation symbol,

$$c = \frac{2}{9}\,\frac{(\mu - 1)^2}{\mu} \qquad (10)$$

where c is the permeance function of a shield of spherical form, the equation takes the form,

$$g = 1 + c\,(1 - p_1 p_2) + c\,(c + 1)\, m_1 m_2 m_{12} \qquad (9\text{-}2)$$

By making $r_2 = R_2$, and therefore, $p_2 = 1$ and $m_2 = 0$, the outer magnetic shell is eliminated and the shield is reduced to a single shell for which the shield factor is

$$\begin{aligned} g_1 &= 1 + c\,(1 - p_1) & (11) \\ &= 1 + c\,m_1 & (11\text{-}2) \end{aligned}$$

or

$$(g_1 - 1) = c\,m_1 \qquad (12)$$

$(g - 1)$ is called the shielding power of a shield.

Equation (11-2) shows that the shield factor of a shield depends not on the absolute size of a shield, but on m; that is, on the relative mass of the shell wall to the size of the shell.

5. See DuBois: *Electrician*, Vol. 40, 1897, p. 317.

In the same way, by making $R_1 = r_1$ and therefore $P_1 = 1$, $m_1 = 0$, we have

$$g_2 = 1 + c\,m_2 \qquad (10\text{-}2)$$

DuBois' equation may now be transformed so as to express g as a function of g_1 and g_2.

$$\begin{aligned} g &= 1 + c\,(1 - p_1 p_2) + c\,(c + 1)\, m_1 m_2 m_{12} \\ &= 1 + c\,[1 - (1 - m_1)(1 - m_2)] + c\,(c + 1)\, m_1 m_2 m_{12} \\ &= (1 + c\,m_1)(1 + c\,m_2) - m_1 m_2 (c^2 + c) + c(c + 1)\, m_1 m_2 m_{12} \\ &= g_1 g_2 + m_1 m_2\,(c^2 + c)\,(1 - m_{12}) \\ &= g_1 g_2 - c\,(c + 1)\, m_1 m_2 m_{12} \qquad (13) \end{aligned}$$

This is the second form of the DuBois' Equation This equation shows that the shield factor consists of two terms. The first is made of two main factors, each being the shield factor of the corresponding shell; and the second or negative term represents the effect of the mutual reaction of the two shells on each other and is a measure of the loss of shielding power due to such reaction. For a pair of shells of given radial ratios (m_1 and m_2 constant), the reaction reaches the maximum value, and g reaches the lowest value when $p_{12} = 1$; that is, when the air space is eliminated.

If the shells are not very thin, and also if the permeability of the shell material and therefore the permeance function of the shield is very high, we can assume $c = c + 1$, and also $c\,m_1 = 1 + c\,m_1$, and $c\,m_2 = 1 + c\,m_2$ approximately; this approximation reduces DuBois' equation to a much simpler and more instructive form:

$$\begin{aligned} g &= (1 + c\,m_1)(1 + c\,m_2) - c\,(c + 1)\, m_1 m_2 p_{12} \\ &= c\,m_1\,c\,m_2 - c^2 m_1 m_2 p_{12} \text{ (approximately)} \\ &= g_1 g_2 - g_1 g_2 p_{12} \text{ (approximately)} \\ &= g_1 g_2 (1 - p_{12}) \text{ (approximately)} \\ &= g_1 g_2 m_{12} \text{ (approximately)} \qquad (13\text{-}2) \end{aligned}$$

That is, the shield factor of the whole shield is approximately the product of the shield factors of the individual shells multiplied by the clearance ratio of the air space between the shells. This form of the equation brings out clearly the function of the air space in improving the efficacy of the shield; it reveals the fact, not obvious at first sight, that a shield made up of two shells, with a non-magnetic space between, is superior to a shield of the same size with all the space filled with the magnetic material. It would appear that the reluctance of a single shell filling the whole space occupied by the shield ought to be less than that of a multi-shelled shield with air spaces between. This view is contradicted by the well recognized fact that a multi-shelled shield with air spaces between is far superior to a solid shield of the same size, although the latter contains much more magnetic material and has apparently much less reluctance. DuBois' formula has been found to be in close agreement with the shield factor obtained by measurement. (DuBois, *Electrician*, Vol. 40, p. 653). In the case of cylindrical shields, the shield factor is given by a similar set of equations:

$$g = 1 + \frac{1}{4}\,\frac{(\mu - 1)^2}{\mu}\Big[(1 - q_1 q_2) + \frac{(\mu + 1)^2}{4\mu}\, n_1 n_2 n_{12}\Big] \qquad (14)$$

where

$$q_1 = (r_1/R_1)^2 \qquad n_1 = 1 - q_1$$
$$q_2 = (r_2/R_2)^2 \qquad n_2 = 1 - q_2$$
$$q_{12} = (R_1/r_1)^2 \qquad n_{12} = 1 - q_{12}$$

Using as before the notation

$$d = \frac{(\mu - 1)^2}{4\mu} \qquad (15)$$

the equation takes the simpler form,

$$g = (1 + d\, n_1)(1 + d\, n_2) - (d^2 + d)\, n_1 n_2 q_{12}$$
$$= g_1 g_2 - (d^2 + d)\, n_1 n_2 q_{12} \qquad (16)$$
$$= g_1 g_2 n_{12} \text{ approximately} \qquad (16\text{-}2)$$

This equation is analogous to that for spheres, and leads to similar conclusions.[6] Incidentally, it may be noted here that the ratio of the permeance functions in the two cases, *viz.*, spherical and cylindrical shells, is

$$\frac{c}{d} = \frac{2}{9}\,\frac{(\mu - 1)^2}{\mu} \Big/ \frac{1}{4}\,\frac{(\mu - 1)^2}{\mu}$$

or

$$\frac{c}{d} = \frac{8}{9} \qquad (17)$$

Rucker has shown that for a shield of predetermined size—that is, when the innermost and outermost radii are specified,—the most efficient shield is obtained when the successive radii of the shells form a geometric progression.

Equations for shields of more than three shells can be developed by further application of the same method, but the work involves a very laborious computation, and the improvement secured thereby is not sufficiently great to justify the effort. A shield of three shells is quite satisfactory for almost all practical purposes, and one of the two shells is good enough for most of them. If necessary, Equation (13-2) can be extended to any number of shells as an approximate formula.

9. Materials for Shells

A reference to DuBois' formula shows that the shielding effect is nearly proportional to permeability; high permeability is therefore the most important requisite for shield material. In practise, the fields against which protection is needed in galvanometer work are generally very weak. The best material for a shield is therefore a material with high initial permeability. It is also necessary to remember that the material should be as free from hysteresis as possible. Material capable of developing strong local poles and retaining them is worse than useless, as it may create more disturbance than it can cure. Fortunately, material of high permeability has generally a very low hysteresis, which simplifies to that extent the problem of choice of material. The newly discovered alloys, permalloy and other alloys of that class, seem to be the best materials for shields but no recorded data on shield ratio for these materials are yet available. Professor Hill states that he has obtained a shield ratio $g = 1000$ by the use of a cylinder of sheet "Mu-metal" rolled with a spacer of sheet copper, and with end plate of Mu-metal. (*Journal of Scientific Instruments*, Vol. 3, 1925-26, p. 335). For steady disturbance fields a massive material is just as good as laminated material, but for disturbance of transient character, massive material is at a disadvantage. The impulsive nature of the disturbance generates an eddy current, which chokes back a part of the flux and prevents it from going through the walls of the shell, thereby reducing the efficiency of the shell, as is indicated by an impulsive kick of the protected galvanometer. Laminated shells have no disadvantage in particular. They are equally efficient against impulsive and steady disturbances. There seems to be some difference of opinion as to the mode of lamination. One method is to prepare a cylindrical shell by stacking a number of ring punchings of appropriate size, a scheme of lamination which simplifies the problem of cutting observation windows in the shield. A second method is to prepare a cylindrical shell by rolling sheet material in the form of a cylinder. Theoretically, the latter type ought to be a trifle better. Practically no great improvements seem to have been observed.

10. Importance of Differential Permeability for Shielding

In view of the facts that the shielding power of a shield depends on its permeability, and that the permeability of every known ferromagnetic material depends on its flux density having a maximum value when the material is carrying a certain amount of flux, attempts have been made to improve the shielding power of a shield by setting up a toroidal flux of sufficient strength to bring the material to the point of maximum permeability. It has been shown that this method of increasing permeability leads to no appreciable improvement in shielding power.[7] The cause of the failure lies in the fact that the permeability on which the shielding power of the shield depends is not normal permeability B/H, but differential permeability $\Delta B/\Delta H$, where ΔH is the new increment of stray field, superposed on the previous field H, with corresponding values for ΔB and B. If the shield be in the non-magnetic condition to start with and be subjected to a toroidal magnetization up to the point of maximum permeability, and if a weak magnetic field be then turned on for the first time, the toroidal magnetization does give a slightly greater shielding power; but a second

6. For similar equations for shields of three shells see "Stalloy Ring Shields," by D. W. Dye. (*Journal of Scientific Instruments*, Vol. 3, 1925, p. 66.)

7. DuBois, *Electrician*, March 11, 1898, Vol. 40, p. 654.

application of the same field is attended by a reduced shielding power. In every case after the first application of the stray field, the iron goes through a small unsymmetrical hysteresis loop, the mean slope of the last side of the loop being the value of permeability, $\Delta B/\Delta H$, which determines the final distribution of the flux. Even in the case of the first application of the field, the improvement is not very great because the values of both ΔH and ΔB are not positive for the whole ring; in one-half of the ring the stray field is opposed to the flux and the corresponding permeability has the value not $+\Delta B/+\Delta H$, but the much lower value $-\Delta B/-\Delta H$. As the shielding power of the shield depends on the final distribution of the flux, which in turn depends greatly on the differential permeability under the working conditions, it follows that DuBois' equation involving the normal permeability B/H, instead of $\Delta B/\Delta H$, is only a first approximation.

11. Failure of the Shield

In the ultimate analysis, the operation of the shield depends on the refraction of the flux lines as they pass through the successive surfaces of the shield. If therefore the lines of flux in any particular case are either strictly perpendicular or strictly parallel to the surfaces of the shield, there can be no refraction and therefore no shielding effect. For example, if one end of a long thin bar magnet is inserted inside a spherical shell, all the lines emanating from the inserted pole will pierce through the shield and emerge as if there were no shield. If, on the contrary, a magnet were inserted inside the shell with both poles inside, the space outside will be almost fully protected by the shell. Only a few lines in the direction joining the poles will be perpendicular to the surfaces of the shell and will emerge outside unchanged; these will be a very small fraction of the total lines emanating from each pole of the magnet. As an example of parallel flux, we may consider the case of a tubular shield with a single wire carrying the current along the axis of the shield. The magnetic field at any point outside of the shield will be just as intense with the shield as without it. These cases of failure do not generally occur in practise, but it was necessary to mention them just for the sake of a correct theoretical understanding of the nature of the phenomenon.

12. Incidental Shielding

Imagine a wire carrying a current held in front of a plane face block of iron of infinite extent on the opposite side and of infinite permeability. The problem is to determine the form of the field and the distribution of magnetism on the surface of the block. A problem of this kind is easily solved by the method of electromagnetic images. Imagine the block removed for a time and another wire carrying a current of the same magnitude and direction located where the image of the first wire would have been formed if the face of the block had been a mirror. Such a current would be an electromagnetic image of the first current; the field at any point in front of the block can be obtained by computing the field produced by the two wires separately and obtaining the resultant effect. For a point immediately near the block, the field would be perpendicular to the face of the block, and the magnetic surface density at any point of the face can be computed from Coulomb's Law.

$$\sigma = H/4\pi \qquad (18)$$

where H is the field at that point as computed by the image method.

This is the method of magnetic images. More important cases occurring in engineering practise are described in Searle's, "Magnetic Field Near a Cylinder of Iron," *Electrician*, Vol. 40, 1898, p. 453.

13. Dynamic Shielding

Imagine a wire carrying a current held in a magnetic field and at right angles to the field. The wire would be subject to a sidewise pull proportional to the product of the field strength and the strength of the current. Now imagine a tubular magnetic shield surrounding the wire but not touching it; the field inside of the shield will be very much weaker and the sidewise pull on the wire will be reduced in proportion. Suppose now that the shield is mechanically fixed to the wire so that the wire and shield must move together or not at all; the pull on the wire is now as strong with the shield as without it. This apparently paradoxical result is due to the fact that when the shield moves with the wire, the lines of flux crossing the space inside the shield move in the opposite direction at a rapid rate with a velocity inversely proportional to the weakening of the field. Therefore, the rate at which the lines are cut by the wire is now the same with the shield as without it.

14. Differential Shielding

The most important practical use of shielding is the protection of moving-magnet galvanometers against the steady terrestrial field in which they work. The galvanometers are generally of the astatic type. In practise, it is nearly impossible to get the necessary exact balance between the two opposing magnets of the system.

An article on the Future of the Residential Lighting Field by M. Luckiesch in the *Electrical World* states that during the past year more than 1,000,000 residential customers have been added to central-station lines. There still remain nearly 9,000,000 residences not being served, of which more than 3,000,000 are within easy reach of central-station lines. Based on the present average wired home, the residential field will use about 135,000,000 lamps for renewals and at least 15,000,000 for initial installations during this coming year. Furthermore, assuming only a normal increase in the number of average customers, we may expect an increase of more than 15,000,000 lamps per year for several years.

ILLUMINATION ITEMS

Submitted
The Committee on Production and Application of Light

WIRING FOR ADEQUATE LIGHTING IN COMMERCIAL AND INDUSTRIAL BUILDINGS

G. H. STICKNEY*

When the lighting of a building proves unsatisfactory to an owner or tenant, it has become common practise to call upon the illuminating engineers of the lamp manufacturers or central station companies for prescription as to proper treatment.

Revamping unsatisfactory jobs provides valuable experience which is not commonly shared by the consultant who deals principally with new installations and seldom contacts with them after they are put in use.

These engineers have therefore become especially familiar with the ills of lighting installations, and it is probable that no other group has as accurate a knowledge of what is demanded of a lighting installation.

Sometime about the year 1922 there was a change in the character of the troubles encountered. Previous to that time it was common to encounter a lack of sufficient outlets, but seldom was there an insufficiency of copper behind the outlets. Since then, inadequate wire capacity has been becoming more and more an impediment to providing sufficient illumination to meet the requirements of the light users.

The constantly increasing demand for ample illumination is of course the main factor, but the change of condition centering about the year 1922 is apparently due in a considerable measure to other causes. In the first place, during the preceding years, the efficiency of tungsten filament lamps advanced rapidly. And since the lamps were made for designated wattage, the light output increased rapidly enough to meet the demands for better lighting. Since then, the increase in light output has been relatively less rapid.

Again, it appears that competitive situations have led the designers of lighting installations to scrimp more and more in order to secure savings in initial costs.

In any event, investigation of lighting complaints indicate that even some of the finest buildings recently erected in the centers of large cities are not only less adequately wired than those of five or ten years ago but, what is really serious, are proving unsatisfactory on first occupation.

It seems almost certain that owners of such buildings will be forced to go to excessive expense to rewire before these installations are five years old, in order to compete with other more adequately wired buildings.

In extreme cases, suitable complements of lamps overtax the safe capacities of the wiring, and blow fuses.

In a much larger number of instances, the inadequate copper size results in an excessive voltage drop so that lamps are operated below their rated efficiency and light output, increasing cost per unit of light delivered to the user. It is not uncommon to find lamps running 20 to 30 per cent low in candlepower. Since the cause is not readily recognized by the layman, the blame frequently falls upon the central station, or upon the lamp or equipment manufacturer.

Obviously, this trouble could be easily avoided at a relatively small additional investment by providing larger wiring capacity in the original installation, whereas rewiring later involves many times that cost.

This situation was recognized several years ago by a few illuminating engineers; and a considerable amount of study has been given to finding a practical way of meeting it, and assuring good advice from the industry.

As the result of representations made by illuminating engineers, the National Electric Light Association, through its Commercial and Industrial Lighting Committee, undertook a carefully planned program.

A first essential was to determine on a reasonable practise. This must be high enough to give assurance of satisfaction in a large majority of installations, and yet not be so high as to prevent wide acceptance.

It was not practical to provide for the few exceptionally well lighted buildings which stand out ahead of ordinary lighting practise.

Furthermore, any specification which can prove acceptable at the present time will need revision upward in a very few years. Fortunately, the reaction to the recommendations which have been published for several years in the lamp manufacturers' bulletins gave a good indication as to a reasonable standard for the quantity element.

Through the experience of some central station illuminating engineers who had written many specifications and followed them through into satisfactory operating installations, it has been found possible to state the quantity features in a few simple paragraphs so directly and simply worded as to avoid any likelihood of misunderstanding. The method is in line with common construction usages.

No attempt was made to produce a complete specification, but the adequacy feature was put in a form suitable for incorporation in the electrical specifications of an architect or consulting engineer.

Although designed primarily for the smaller building, for which consulting engineering advice is not ordinarily retained, the material should prove helpful for larger buildings as well.

These Specification Paragraphs are based upon 15-ampere fusing of branch circuits. Wire of Nos. 10 and 12 B. & S. gage is called for according to the length of the circuit. The number of circuits required is definitely indicated in terms of floor area and initially planned lighting load. Panel boards are specified to allow for a 20 per cent expansion in number of circuits. The capacity and allowable voltage drop of feeders are specified; also over-sized conduit is required.

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Certain other requirements of ordinary installations are covered in simple wording. Practically every feature, with the exception of the feeder sizes, can be interpreted and checked accurately by a layman, without recourse to wiring resistance formulas or tables.

Because of differences in local ordinances and regulation a slight amount of variation is provided, to adapt the specifications to certain cities.

Because of this, and the fact that a certain amount of promotional effort is necessary to secure the adoption of the higher practise, it is proposed to introduce the Specification through the lighting service engineers of the central station companies.

The Specification Paragraphs have already been found acceptable to the Wiring Committee of the National Electric Light Association and to the Society for Electrical Development. The latter organization has in cooperation with the N. E. L. A. Commercial and Industrial Lighting Committee transposed the paragraphs into the suggestive form, and incorporated them in the supplementary section of the Franklin Red Seal Lighting Specifications.

The N. E. L. A. Commercial and Industrial Lighting Committee has outlined a program of advertising in architectural papers, in order to point out to architects the importance of the problem and encourage a local cooperation with lighting service engineers in its solution.

Because of the clearness of the new specifications it is believed that those architects who have been referring the wiring specifications to contractors competing for the work will find it practicable and desirable to resume the control of the wiring, at least so far as lighting circuits are concerned.

In order to prepare lighting service engineers for their responsibility in the program, two national conferences of instruction have already been held, and others are projected locally.

The N. E. L. A. has enjoyed the cordial cooperation of the Structural Service Department of the American Institute of Architects. That organization has not only given valuable advice as to all the features of the program, but has furnished speakers for the conferences. Leading architects and architectural editors have elucidated the architects' ideals and problems, and have given valuable hints on how to deal helpfully with architects.

Moreover, the cordial reaction of these leaders to the specification idea and to the plan in general seems to foreshadow a cordial reception throughout the country.

The altruistic character of the enterprise is indicated by the fact that none of those actively responsible for the undertaking has any direct interest in the sale of wiring, and can gain only through the resulting removal of a resistance to good lighting practise, and then only as such lighting is desired by its users.

A high order of service and cooperation is being offered which may lead much further than the lighting field and induce a constructive cooperation of all concerned in the electrical features of building construction.

What has been done so far is only the first step in a great advance which will take place as fast as excellence is proved.

A NEW LABORATORY OF APPLIED LIGHTING

D. W. Atwater[1]

To further the adequate and proper use of light, the Westinghouse Lighting Institute was opened on May 30, 1929 at the Grand Central Palace in New York

Mazda Avenue of the Westinghouse Lighting Institute is a Complete Street, with Signs, Show Windows and Street Lights

City. Occupying practically an entire city block and having an area of approximately 40,000 sq. ft., it permits a full-sized realistic setting for each lighting application. Through the center of the institute is a city street com-

Exterior View of the Well Lighted Home at the Westinghouse Lighting Institute. It Includes Six Rooms Completely Furnished and Equipped to Show Modern Residence Lighting Practise

plete with its lights, traffic signals, signs, and show windows. Along each side is a variety of buildings including different types of stores, an industrial plant, a garage and filling station and even a six-room house. Behind these actual facades are equally realistic

1. Commercial Engineering Dept., Westinghouse Lamp Co. Bloomfield, N. J.

interiors where lighting effects are demonstrated in proper surroundings. Subjects too large to include in full size,—such as, an airport or a modern office building,—are reproduced in the form of models; however, there are, full-sized sections of street railway cars, busses, and an actual automobile.

Two main distribution boards serve 22 lighting and 7 power panels. There are over 800 switches at 52 control points, 450 double convenience outlets and over 4000 sockets. The connected load adds up to 750 kw. With the exception of a few "hot" outlets for electric clocks and water coolers, everything is operated by magnetic contactors. Over 300 of these are located on 9 contactor panels in soundproof rooms. The contactor rooms are interconnected to permit maximum flexibility; in fact, any switch at any location can be arranged to control any effect.

The Westinghouse Lighting Institute is in reality a laboratory of applied lighting designed and equipped so that it may be of maximum service to both the engineer and the layman, who will find facilities and examples suited to their every need.

LIGHTS' GOLDEN JUBILEE CELEBRATIONS

The observance of Lights' Golden Jubilee will culminate on the twenty-first of this month with the dramatic celebration at Dearborn, Michigan. There, in the original laboratory transported with other buildings from Menlo Park, Mr. Edison will reconstruct in darkness the incandescent lamp and cause it to light. The Edison Pioneers, Mr. Henry Ford, and other distinguished friends of the inventor will be present. Plans have been made for the attendance of President Hoover, who is honorary chairman of the movement. A description of the events at Dearborn will be broadcast over an international radio hook-up.

Lights' Golden Jubilee commemorates Mr. Edison's invention of the incandescent lamp on October 21, 1879. Inaugurated by a brilliant electrical festival at Atlantic City on May 31, during the N. E. L. A. Convention, the Jubilee has been widely observed throughout the country. At Niagara Falls a pageant parade was held, and the Falls were illuminated. During the National Air Races at Cleveland, Ohio, August 31 was dedicated to Edison. The Lights' Golden Jubilee Derby, a race of air-mail pilots, was held with the goal Milan, Ohio, the inventor's birthplace. The American Legion, in its annual convention at Louisville, Kentucky, devoted the opening night, September 30, to Edison. Special golden lamps were used in decorating the business district of the city.

The Government has cooperated in the Jubilee by issuing a two-cent postage stamp in commemoration of the invention; over three hundred and thirty millions of these stamps have been purchased.

The governors of twenty-seven states have already agreed to lend an official character to the celebration by their proclamations. Perhaps the most original, and surely the imaginative plan of celebration has been sponsored by the Oklahoma Utilities Association, which has obtained the cooperation of civic organizations throughout the state. Citizens of Oklahoma will be asked to use candles or kerosene lamps in their offices and homes, for a short time on the twenty-first. Then, at a given signal, all electric lights will be turned on, thus emphasizing the transformation wrought by the invention.

The world-wide importance of Edison's lamp is indicated by the international character of the Jubilee celebration. Plans to cooperate have been made in Argentina, Austria, Canada, Chile, China, France, Germany, Holland, Italy, Japan, Mexico, Peru, Porto Rico, and Sweden.

HOW FAR DOES A KILOWATT-HOUR TRAVEL?

A review of the movement of electric power during the past few years indicates that the average distance traversed by the average kilowatt-hour in its path from power house to consumer in the United States is about 22 mi., according to the Statistical Research Department of the National Electric Light Association. If the production of the state of California, with its power plants for the most part in the Sierras and its use in the lowlands along the seacoast, is excluded, the average for the rest of the United States is only 18 miles. It would seem therefore that in spite of the extraordinary progress in the interconnection of electric light and power systems and the extension of transmission lines during recent years, the great bulk of electric energy is still consumed in the vicinity of the power plants.

To a large extent this is the result of economic factors which have dictated the location of steam plants in the near neighborhood of the large markets for their power in our seaboard cities and the great industrial regions of the country. It is also the result of the increasing economies being effected in the generation of electricity by steam near the centers of use as compared with the cost of making water power developments at a distance and of bringing this power to market over long transmission lines.

Statistics indicate that this average distance traveled by electric power is becoming shorter and that this trend should gradually become more pronounced. Although the production of hydro-electric power (for the most part from distant plants) was larger than the average during 1928, this represents a situation which probably will not persist, the Statistical Research Department further points out. Many of the projects recently completed were determined upon and prepared for at least five years ago when the price of coal was at its peak and when the efficiency of steam generation was much lower than it is at present. Since then, the operating cost of generating electricity by steam have been cut nearly in two and as a result the attractiveness of most of the remaining undeveloped water power plants has been seriously impaired, it is said. Five years from now, the oft-repeated prediction as to the shrinkage in the proportion of the total amount of electric energy produced by water power will, in all probability, be measurably fulfilled.—*Transactions I. E. S.*

INSTITUTE AND RELATED ACTIVITIES

The Chicago District Meeting

LIVE TOPICS TO BE PRESENTED

A noteworthy group of technical papers has been arranged for the District Meeting to be held at the Drake Hotel in Chicago, December 2 to 4. Some of the very latest developments in several lines of electrical engineering, such as distributing stations, double-winding generators, high-voltage generators, fault busses, high-pressure steam, new-type lightning arresters, air-transport communication and other subjects as shown in the list below will be covered.

A Student Session also is planned and entertainment features are being arranged. Further details will be published in the November issue of the JOURNAL.

PAPERS FOR CHICAGO MEETING

The Future of Higher Steam Pressures, I. E. Moultrop, Edison Electric Illuminating Company of Boston.

Use and Design of Fault Ground Bus, R. M. Stanley and F. C. Hornibrook, Byllesby Engineering and Management Corp.

Increased Voltages for Synchronous Machines, C. M. Laffoon, Westinghouse Electric and Manufacturing Co.

Double Windings for Turbine Alternators, P. L. Alger, E. H. Freiburghouse and D. D. Chase, General Electric Company.

Theory of a New Valve Type Lightning Arrester, J. Slepian, R. Tanberg and C. E. Krause, Westinghouse Elec. & Mfg. Co.

A 40,000-Kv. Variable-Ratio Frequency-Converter Installation, E. S. Bundy, Niagara Lockport & Ontario Power Co. and A. Van Niekirk and W. H. Rodgers, Westinghouse Elec. & Mfg. Co.

Low-Voltage A-C. Networks, R. M. Stanley and C. T. Sinclair, Byllesby Engineering & Management Corp.

An Economic Study of an Electrical Distributing Station, W. G. Kelley, Commonwealth Edison Company.

Experience with Carrier-Current Communication on a High-Tension Interconnected Transmission System, Philip Sporn and R. H. Wolford, American Gas & Electric Company.

Automatic Regulation for Synchronous Condensers Equipped with Superexcitation, L. W. Thompson and P. J. Walton, General Electric Company.

Polyphase Induction Motors, W. J. Branson, Robbins & Myers, Inc., Springfield, Ohio.

Recording Torque Indicator, G. R. Anderson, Fairbanks, Morse and Company.

Effect of Armature Resistance on Stability of Synchronous Machines, C. A. Nickle and C. A. Pierce, General Electric Company.

Ionization Currents and the Breakdown of Insulation, J. J. Torok and F. D. Fielder, Westinghouse Electric & Mfg. Co.

Heat Radiation in Inter-Reflection Cases, Professor A. D. Moore, University of Michigan.

Recent Developments in Telephone Toll Service, W. H. Harrison, American Tel. & Tel. Company.

The Chicago Toll Telephone Office, E. O. Neubauer and G. A. Rutgers, of Illinois Bell Telephone Company.

Manufacture of Telephone Carrier and Repeater Apparatus, R. G. Glasier, Western Electric Company.

Air Transport Communication, R. L. Jones, Bell Telephone Laboratories, Inc.

The General Convention Committee which is arranging the meeting is as follows: W. T. Ryan (Vice-President in District No. 5) Chairman; T. G. LeClair, Vice-Chairman; A. G. Dewars, Secretary; J. H. Kuhlmann, M. A. Faucett, Oscar Gaarden, L. F. Hickernell, P. B. Juhnke and F. H. Lane. The chairmen of the other committees which have been appointed to date are: *Technical Program*, F. H. Lane; *Hotel and Registration*, J. E. Kearns; *Finance*, K. A. Auty; *Trips and Transportation*, H. E. Wulfing; *Publicity*, F. R. Innes; *Entertainment and Banquet*, H. W. Eales, and *Student Activities*, J. H. Kuhlmann.

World Engineering Congress

TOKIO, JAPAN, OCTOBER-NOVEMBER 1929

The date of departure of the main body of American engineers who will attend the above mentioned Engineering Congress is rapidly approaching. During the past two months a considerable number of foreign engineers have been arriving in the United States to join the American delegation, which sails from San Francisco October 10. Instead of proceeding directly eastward, the Europeans are taking this opportunity of visiting the United States and inspecting the various engineering and industrial organizations.

The New York City Committee headed by Roy V. Wright, President of the United Engineering Society, made careful plans for the reception of the European visitors and for their entertainment while in New York. The first arrivals included Doctor Karl Koettgen, President, and Doctor Konrad Matschoss, Director, of the Verein Deutscher Ingenieurs. Other arrivals have included engineers from England, France, Germany, Sweden, Denmark, Italy, and Belgium. The total number of Europeans passing through New York on their way to Tokio will be approximately one hundred. The American delegation will constitute about 250 members.

A dinner was given at the Engineers Club in New York on the evening of September 12, in honor of the European delegates who were in New York at that time. Doctor Elmer A. Sperry, Chairman of the American Committee, presided. Doctors Koettgen and Matschoss were the principal speakers of the evening.

Various other dinners and luncheons have been given in honor of the visitors.

On September 18, Doctor Koettgen gave a luncheon in New York to about forty representatives of the various engineering societies.

A farewell dinner in honor of the American and European delegates to the Congress was given at the Hotel Astor, New York, the evening of Thursday, September 26. The occasion afforded a very enjoyable opportunity for foreign and American delegates to become acquainted. The speakers were: Mr. G. S. Davison (toastmaster), Mr. Frank Gill, of England, Senatore Luigi Luiggi, of Italy, Mrs. Roy Wright, Chairman of the New York Ladies Reception Committee, Mr. Gano Dunn, and Mr. Elmer A. Sperry, Chairman of the American Committee of the Congress.

The greater number of both the Americans and Europeans will depart from New York in a special train on the morning of October 2, reaching Washington the same afternoon and visiting President Hoover, Honorary Chairman of the American Committee, at the White House. The same evening the Japanese Ambassador will be the host at a dinner at the Mayflower. The next day the special train will continue its way westward where various events for the entertainment of the visitors have been arranged by the local committees of engineers in Chicago, Los Angeles, and San Francisco. The train will stop one day at the Grand Canyon.

The delegates will sail from San Francisco October 10 on the *President Jackson* of the Dollar Line and the *Korea Maru* of the Nippon Yusen Kaisha. All accommodations on these two ships having been reserved some weeks ago, it was necessary for some of the delegates to take other steamers from Seattle and Vancouver.

The list of A. I. E. E. members who are planning to participate in the Congress includes:—Messrs. Harry Alexander, M. W.

Alexander, Ivan F. Baker, Axel F. Enstrom (Sweden), H. B. Gear, Frank Gill (London), Clotilde Grunsky, F. C. Hanker, E. M. Herr, Maurice Holland, F. L. Hutchinson, D. C. Jackson, B. G. Jamieson, Frank B. Jewett, Paul M. Lincoln, O. C. Merrill, W. S. Murray, L. A. Osborne, H. G. Reist, Calvin W. Rice, David B. Rushmore, Wellington Rupp, R. F. Schuchardt, Chas. E. Skinner, Elmer A. Sperry and Chas. W. Stone.

An executive committee of the A. I. E. E. group was appointed by President Smith, in accordance with the authorization of the Board of Directors, consisting of Messrs. F. B. Jewett, Chairman, F. L. Hutchinson, D. C. Jackson, R. F. Schuchardt and C. E. Skinner.

The program to be presented at the Congress includes a large number of papers on all branches of engineering. The complete list of these papers is not yet available.

New York Electrical Society to Hear About Hudson River Bridge

The extraordinary problems and massive figures of construction involved in the building of the mighty Hudson River Bridge, largest suspension bridge in the world, will be the subject of the next meeting of the New York Electrical Society, to be held in the Engineering Auditorium, 29 West 39th St., on Wednesday, October 16th, at 8:15 p. m. Edward S. Stearns, Assistant to the Chief Engineer of Bridges of the Port of New York Authority, will be the speaker. Mr. Stearns will not only have slides to illustrate this lecture, but also plans to show a complete set of motion pictures of the progress of construction. Of even greater appeal will be the carefully detailed and proportioned series of models of the bridge, bridge approaches, cable cross-sections, etc., which the speaker will use to emphasize more sharply the many features of his talk on this enormous undertaking. From these models, built by the engineers to aid them in the study of traffic and construction problems, an unusually clear idea of the actual conditions to be observed at the completion of the great span can be gained.

On Saturday afternoon, October 19th, the members and guests of the New York Electrical Society will take a special trip to the Hudson River Bridge in busses, from some given point of departure, and in order to gain a final idea of the enormity of this work, will be taken in small parties with guides over both the New York and New Jersey properties. Of particular interest will be the opportunity to watch the wire-spinning operations, for which arrangements are being made for observation from a special point of vantage.

There will be a charge to cover bus fare, etc. Full details may be obtained from the Secretary F. M. Delano, 29 West 39th St., N. Y.

The National Fuel Meeting to be Outstanding

The Third National Fuels Meeting held under the auspices of the Fuels Division of The American Society of Mechanical Engineers will open on the morning of October 7th in the Bellevue-Stratford Hotel, Philadelphia, Pa., and continue through the 10th, with one of the most outstanding programs ever arranged by the Fuels Division.

There is every expectation that this meeting will set a new mark in quality of papers and in attendance, for, in line with its announced purpose of making these conferences fuels forums where all engineers may come for aid and for the exchange of experiences, there has been a real effort to obtain constructive recommendations from organizations interested.

These suggestions have been of inestimable value to the Program Committee and it hopes for stimulating effect for future meetings and for engineers in general, regardless of their society affiliations.

The technical program will be contributed to by specialists in the fields of fuel production and utilization, on the general subjects of power-plant problems, low-temperature carbonization, industrial fuel problems, the domestic heating situation, stokers, and smoke abatement. Over thirty papers are scheduled.

STANDARDS

New Standards Binder Available

A new A. I. E. E. Standards binder has just become available which it is felt will be more effective than its predecessor from every point of view. In appearance it is similar but is considerably less bulky. At the same time it not only holds the present entire set of A. I. E. E. Standards and Reports but there is still room for quite a number of additional pamphlets. Two steel bars are passed through punchings in the pamphlets. They are held firmly in place, yet it is much easier to insert either a whole set or an individual pamphlet. All pamphlets are now issued properly punched to fit the new binder. No clips nor rods are necessary. The price has not changed; it is $1.75 per binder.

Standard Dimensions for Polyphase Induction Motors

There is before the American Standards Association a proposal for adoption as American Standard, a table of dimensions for polyphase squirrel-cage open type general purpose induction motors, 60 cycles, 110-220, 440 and 550 volts. This covers motors of all types of bearings, from one-half to 30 hp. and speeds of 900, 1200, and 1800 rev. per min. This proposal is being put forward by the National Electrical Manufacturers Association, whose Standards Committee approved the table September 11, 1929. For copies of this table apply directly to N. E. M. A. headquarters, 420 Lexington Ave., New York, N. Y.

Symbols for Hydraulics

An American Tentative Standard on "Symbols for Hydraulics" which was approved by the American Standards Association on July 10, 1929 is now available in pamphlet form. This was developed by the Sectional Committee on Scientific and Engineering Symbols and Abbreviations. A copy of the Standard may be obtained at a cost of 35 cents by writing to headquarters of American Society of Mechanical Engineers, 33 West 39th St., New York, N. Y.

Navigational and Topographical Symbols

A subcommittee of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations has completed a report on Navigational and Topographical Symbols. This report is now up for approval by the sponsor bodies and will then be offered for approval as American Standard under the procedure of the American Standards Association.

The Pacific Coast Convention

SANTA MONICA, CALIF., SEPTEMBER 3-6, 1929

The eighteenth annual Pacific Coast Convention was held at the Miramar Hotel, Santa Monica, Calif., September 3-6, 1929, with the Los Angeles Section acting as host. The total attendance was approximately 440, and there were many very favorable comments regarding the quality of the technical programs as well as the attractiveness of the entertainment features. In the eighteen papers presented at four of the technical sessions, subjects of a wide variety were discussed, and an interesting illustrated address was given on Wednesday evening by Doctor William V. Houston of the California Institute of Technology.

STUDENT ACTIVITIES

The technical sessions on Tuesday afternoon and Thursday forenoon were devoted to the presentation of technical papers prepared by engineering students in the Pacific and Northwest Districts. Under the approval of the Board of Directors granted in 1927, a Joint Conference on Student Activities of the two

Districts was held. More complete reports on all Student Sessions are given in the Student Activities Department.

Entertainment

The informal reception and dance held on Tuesday evening opened the social program of the convention in a most enjoyable manner.

The principal social event was the banquet held Thursday evening with President Harold B. Smith presiding. President Smith presented A. I. E. E. prizes for papers in the Pacific District, No. 8, for 1928, as follows:

Regional First Prize—*Sphere-Gap and Point-Gap Arc-Over Voltage as Determined by Direct Measurement*, by J. S. Carroll and Bradley Cozzens

Regional Prize for Initial Paper—*Automatic Mercury Arc Power Rectifier Substation on the Los Angeles Railway*, by L. J. Turley

Regional Prize for Branch Paper—*The Effect of Barriers in Insulating Oil*, by P. E. Warrington

All of these papers were presented at the 1928 Pacific Coast Convention. Each prize consisted of $25.00 paid from the Institute treasury and a certificate issued by the District Officers. Several vocal selections rendered by Sylvelin Jarvis, lyric soprano, contributed much to the evening's program. L. C. Williams, Chairman of the Ladies' Entertainment Committee presented two prizes for the ladies putting contest held Thursday morning and seven for the bridge contest held Thursday afternoon. As results of a drawing, involving all persons holding banquet tickets purchased before a previously specified time, three attractive prizes were presented.

Twelve very attractive and useful prizes were presented by Harold Thrane, Chairman of the Golf Committee to winners in the golf tournament held on Wednesday. The John B. Fisken cup and first prize,—a suit case,—were won by E. W. Rockwell of Los Angeles, C. E. Fleager of San Francisco, Vice-President, District No. 8, receiving the second prize,—a set of wooden clubs.

After Doctor Houston's address on Wednesday evening, recent developments in sound pictures were explained and then illustrated by showing the new sound pictures, "Fast Company" and "Three Live Ghosts."

Other events for the ladies were a luncheon and an informal reception and bridge on Tuesday, and dancing Wednesday evening; also trips to many points of interest.

Trips

In addition to a considerable number of trips to power plants, substations, the California Institute of Technology, and other places of interest, there were available on Wednesday all-day trips to Catalina Island and Mount Lowe, and beginning on Saturday, two-day trips to Catalina Island and Aguaa Cliente. Also an all-day trip to Agua Caliente by airplane was available to those interested.

The 1930 Convention

A luncheon meeting of officers of the A. I. E. E., the Pacific and North West Districts, and representatives of the Pacific Coast Sections was held Thursday, and it was decided to recommend that the 1930 Pacific Coast Convention be held in Portland, Oregon, at a time to be chosen by the Portland Section.

Technical Sessions

At the close of the Friday afternoon technical session, J. P. Jollyman of San Francisco expressed, in behalf of the guests, very sincere thanks to Chairman Northmore and his committees for the welcome received and the superior programs provided.

A summarized report of the discussions during the technical sessions will be published in the November issue of the Journal.

Convention Committee

Much praise is due the General Convention Committee and the subcommittees for the excellent plans prepared in advance and for the actual conduct of the various features of the convention. The officers of the General Committee and the Chairmen of the Subcommittees were; E. R. Northmore, *General Convention Chairman*; H. L. Caldwell, *Assistant Chairman*; N. B. Hinson, *Chairman Finance Committee*; W. H. Hitchcock, *Secretary*; Gordon Nott, Subcommittee on *Registration*; E. R. Stauffacher, *Technical Papers*; R. W. Sorensen, *Student Technical Papers*; R. A. Hopkins, *Entertainment*; J. H. Cunningham, *Publicity*; F. E. Dellinger, *Hotels*; Harold Thrane, *Golf*; L. C. Williams, *Ladies Entertainment*; H. H. Cox, *Transportation*.

Eminent Hydraulic Engineer Visits America

Doctor Dieter Thoma, Professor and Director of the Hydraulic Institute of the Technical University of Munich, who arrived in New York September 15, and who is especially well known for his work on model studies, pumps, and turbines, will give an extensive series of lectures at Massachusetts Institute of Technology, October 2-28 inclusive. Following this, he will make a tour of the United States, visiting points of special interest to hydraulic engineers, and delivering lectures before other engineering and scientific organizations.

Doctor Thoma last visited America in 1925, when his travels took him as far west as the Pacific Coast. He is a member of numerous technical and scientific bodies, among which are The American Society of Mechanical Engineers and Verein Deutscher Ingenieure.

AMERICAN ENGINEERING COUNCIL

Fall Meeting Administrative Board

The call for the fall meeting of the Administrative Board of American Engineering Council has been issued by the Executive Secretary, L. W. Wallace. The meeting will be held at the Mayflower Hotel, in Washington, D. C., October 24-5.

The Executive Committee will meet in the office of the Executive Secretary, 26 Jackson Place, Washington, D. C. on Thursday, October 24.

The Administrative Board will hold its sessions in the Jefferson Room of the Mayflower Hotel, the first session to convene on Thursday, October 24. The second session will open Friday, October 25, and the third, the afternoon of the 25th.

Members of the Administrative Board who are expected to attend are:

A. W. Berresford, President; Doctor H. E. Howe, Treasurer; L. W. Wallace, Executive Secretary; L. P. Alford, O. H. Koch, I. E. Moultrop, G. S. Williams, Vice-Presidents; E. F. Wendt, American Institute of Consulting Engineers; Col. J. H. Finney, M. M. Fowler, H. A. Kidder, Farley Osgood, R. F. Schuchardt, and C. E. Skinner, of the American Institute of Electrical Engineers; Professor William Boss, of the American Society of Agricultural Engineers; H. S. Crocker, A. J. Dyer, G. T. Seabury, F. M. Williams, American Society of Civil Engineers; John Lyle Harrington, William S. Lee, Gen. R. C. Marshall, Jr., Charles Penrose, Elmer Sperry, D. Robert Yarnall, American Society of Mechanical Engineers; Regional Districts, No. 1, G. A. Reed; No. 2, B. A. Parks; No. 3, J. S. Dodds; No. 4, Doctor J. R. Withrow; No. 5, A. A. Krieger; No. 6, H. A. Marshall; No. 7, C. H. Koch.

Appointments to the Assembly

At the meeting of the Board of Directors of the Institute held August 6th, the following nine members were appointed as representatives of the Institute to the Assembly of American Engineering Council for the two-year term beginning January 1, 1930:

*F. J. Chesterman
*M. M. Fowler
*H. A. Kidder
W. S. Lee
*William McClellan
*L. F. Morehouse
*I. E. Moultrop
Harold B. Smith
L. B. Stillwell

The other nine Institute representatives to the Assembly of Council, now in office for term of service expiring January 1, 1931, are as follows:

H. H. Barnes, Jr.
A. W. Berresford
C. O. Bickelhaupt
F. L. Hutchinson
Farley Osgood
R. F. Schuchardt
Charles F. Scott
C. E. Skinner
Calvert Townley

*Reappointed.

Doctor Hague Visiting Professor at Brooklyn Polytechnic Institute

Doctor Bernard Hague, Principal Lecturer in Electrical Engineering at the University of Glasgow, Scotland, has accepted the invitation of the Polytechnic Institute of Brooklyn to serve as Visiting Professor of Electrical Engineering at Polytechnic for the present academic year. Doctor Hague, who has degrees from the Universities of London and Glasgow, is the holder of the Siemens Medal for Electrical Engineering and the Henrici Medal for mathematics as well as the diploma of the Imperial College of Science for Postgraduate Research. He is a member of the Institution of Electrical Engineers, the author of several standard works on electrical theory and measurements, and is a recognized authority in this field. At Brooklyn Polytechnic he will have charge of the conduct of graduate study and research in electrical engineering in the new plan now being developed at that institution for the benefit of technical graduates in the metropolitan district who desire to earn advance engineering degrees by evening study.

World Power Conference

BERLIN, JUNE 1930

Plans are in progress for a plenary meeting of the World Power Conference to be held in Berlin, June 1930. The American Committee of the World Power Conference gave a dinner at the University Club, New York, September 11, in honor of the President, Secretary and other members of the German National Committee. Chairman O. C. Merrill of the American Committee presided.

The chief aim of this second World Power Conference, which it is expected will be attended by delegates from fifty-one nations, according to a statement by Doctor Koettgen, President of the German Committee, is to further the general scientific knowledge of the world in matters pertaining to power distribution, operation and economics. Doctor Koettgen reported that it is expected that more than 250 papers, including those from America, will be presented at the Conference.

Information regarding the purposes and scope of the Berlin Conference may be obtained by addressing O. C. Merrill, General Chairman, American National Committee, World Power Conference, 917-15th St., N. W., Washington, D. C.

A Highway Safety Campaign

Stirred to action by the increasing number of deaths by traffic, the Traffic Committee of the American Road Builders' Association is sponsoring its third annual highway safety campagin.

A survey is being made with a view to ascertaining remedies effective in halting this loss of life and it has been found, according to the Association, that proper measures for safety lie in the building of highways and also with the vehicles operating over them; the greatest blame, according to all previous investigations, may be laid at the door of the reckless driver and the unheeding pedestrian. Pedestrians should obey traffic laws. There can be no safety where one group of traffic moves under strict regulation with traffic lights and police direction, while, in the same area, another group moves as it pleases. Traffic laws must of necessity be practical and of a nature to speed traffic movement. It requires law and the enforcement thereof.

Rosenwald Industrial Museum

A Museum of Science and Industry has recently been founded at Chicago by Julius Rosenwald. In this will be attempted something which has never before been undertaken in this country: to give a unified presentation of the whole field of technology, industry, engineering, and science on which our modern civilzation is based. Electrical engineering, because of its importance in our present civilization, will occupy a prominent place in the museum. In addition to the present state of the various industrial processes and the scientific knowledge on which they depend, it is aimed to show the historical development of the same processes, industries, machines, and sciences. This is to be done through the medium of models and originals of both historical and modern machines, which in many cases will be cut open to show their construction, and which will be in motion whenever possible; and by other exhibits and displays, supplemented by diagrams and motion pictures.

This is a large undertaking. The example and experience of several European technical museums is available, but the cooperation of American engineers is needed also.

The following communication from Edward W. Kimbark, Assistant Curator of Motive Power and Transportation suggests two ways in which the cooperation of engineers might be expressed:

"First, by informing us of the location of any machinery or apparatus of historical value, which might possibly be acquired by the Museum, and by donating such apparatus in their possession. There are undoubtedly many articles of antique vintage lying in odd corners of stores and factories, or even on junk heaps, cast aside many years ago to make way for more modern apparatus. Many of these articles could serve a useful purpose if they were brought into the light of day and arranged in proper historical sequence with other articles of the same kind, so as to make evident to the museum visitor the steps of development in a certain field.

"We have recently learned that a Newcomen engine stood for many years on the shores of Newark Bay and was finally junked because no institution would give it a permanent home. The big Corliss beam engine that ran the Pullman Works met a similar fate. It is quite conceivable that there are still in existence many of these technical relics, in some inconspicuous corner.

"We should like to appeal to your readers who may know of the location of some invaluable pieces of apparatus which might well find a home in the first industrial Museum in America. If so, their communications, addressed to the director of the Museum of Science and Industry, 300 West Adams Street, Chicago, will be most welcome.

"A second way in which the engineers of America can be of service to us is by giving us suggestions for exhibits and by allowing us to call on them for advice."

ENGINEERING FOUNDATION

ALLOYS OF IRON RESEARCH

At a dinner at the University Club the evening of September 25, H. Hobart Porter, of Engineering Foundation signalized the beginning of the activities of the Iron Alloys Committee's work to obtain basic data on iron and its numerous combinations with other metals and certain metalloids. Notwithstanding the rapid progress made during recent years, the committee feels

that knowledge of the possibilities of iron alloys and steel alloys has scarcely more than begun. Much more information is needed and to meet this need, data must be collated from laboratories of industries, governmental bureaus, universities, and other institutions of several countries. These data have already found their way into many publications and a score of languages, but to many busy men, they are not yet available, and there has been a wasteful duplication of effort and loss of time. The Iron Alloys Committee has therefore accepted as its first duty the culling from present voluminous literature results obtained by researchers, technologists, and engineers, and putting the results of this review into monographic form. The second step will be to organize and promote researches for new basic information with regard to pure iron and its combinations with other substances,—not for commercial alloys, but simply for the underlying facts essential to all industrial metallurgical laboratories.

Appointments to this Committee are: George B. Waterhouse, Professor of Metallurgy, Massachusetts Institute of Technology, Chairmen: George K. Burgess, Director, National Bureau of Standards; (Louis Jordan, of the Bureau, alternate); Scott Turner, Director of the United States Bureau of Mines (Charles H. Herty, Jr., alternate) R. E. Kennedy, Technical Secretary, American Foundrymen's Association; H. W. Gillett, Director, Battelle Memorial Institute; Bradley Stoughton, Director, Metallurgical Engineering Department, Lehigh University; Jerome Strauss, Chief Research Engineer, Vanadium Corporation of America; T. H. Wickenden, Metallurgical Engineer, the International Nickel Company; and John A. Mathews, Vice-President of the Crucible Steel Company of America. The Committee has also enlisted the cooperation of the four national societies of mechanical, civil, mining, and electrical engineering, as well as the American Iron and Steel Institute, the Society of Automotive Engineers, the American Society for Steel Treating, the American Society for Testing Materials, the National Bureau of Standards, the United States Bureau of Mines, universities and numerous corporations in metallurgical industries.

VOLUME III OF RESEARCH NARRATIVES

The new Volume III of Research Narratives, to which publicity was given on page 715 of the September issue of the Institute's Journal, is available at the price of one dollar per copy by application to the office of Alfred D. Flinn, Director, 29 West Thirty-Ninth Street, New York, N. Y.

PERSONAL MENTION

Joseph Rah, formerly chief engineer of the G & W Electric Specialty Company, is now connected with the Delta-Star Electric Company, Chicago, in a consulting capacity.

Edmond S. McConnell, formerly Assistant Electrical Engineer, The American Brass Company, Waterbury, Connecticut, has been transferred to Chicago where he has accepted a position as Sales Engineer with Anaconda Wire & Cable Company, an affiliated company with western offices at Chicago.

Lyle W. Wickersheim, on September 1, 1929, was transferred from the Southern California Telephone Company's General Engineering Department in Los Angeles, to the Toll Systems Development Department of the Bell Telephone Laboratories, Inc., New York City.

Gerald Pickett has resigned his position as Junior Material Engineer at the Material Laboratory of the Brooklyn Navy Yard to accept an appointment as Instructor in Applied Mechanics Department at the Kansas Agricultural College, Manhattan, Kansas.

George A. Jacobs, formerly president of the Dudlo Manufacturing Company, of which he was the founder, has organized the Inca Manufacturing Company, Fort Wayne, Ind., which will specialize in magnet wires and windings. Mr. Jacobs graduated from Worcester Polytechnic Institute in 1900 and has been an Associate of the Institute since 1917.

Edward L. Behrens, who for the past four years has been in charge of works engineering for the five General Motors Corporation plants located in Saginaw, Mich. has recently been engaged by the Detroit Division of Solvay Process Co. as its Electrical Engineer. His capacity is that of consultant to manufacturing maintenance and construction departments.

Z. H. Hu, who was appointed by the Chinese Government to study the telephone systems in foreign countries, left the New Jersey Bell Telephone Company in April and has now completed his study in the United States. He will leave for Europe shortly to continue his work in England, France, Belgium, Germany and Switzerland.

A. L. O'Banion, who for the past five years has been an instructor in electrical engineering at Cornell University, has been appointed Professor of Electrical Engineering at Clemson College, South Carolina, to take the place of Professor S. R. Rhodes who has been promoted to Head of the Division of Electrical Engineering to succeed Professor Dargan.

Ernest V. Pannell, Technical Adviser to The British Aluminium Co. Ltd., in New York for the past ten years, will sail for England shortly to take over the management of The London Aluminium Co. Ltd., Birmingham, England, a manufacturing concern specializing in stampings and other fabricated forms of aluminum and light alloys.

Obituary

Walter Clark Fish, Electrical Engineer and formerly General Manager of the General Electric Company's Lynn Works, died September 8, at his home in Boston, after an extended illness of several years' duration. He was born in Taunton, Massachusetts, August 25, 1865, spent two years at Harvard, and subsequently was graduated from Massachusetts Institute of Technology. He joined the Thomson-Houston Company at Lynn and in laboratory research work was associated with Professor Elihu Thompson. In testimonial of the efficiency of his work, Professor Thompson asserted that "through his energy, skill and care, Mr. Fish contributed much toward maintaining a high standard for all work done." In 1888 he was representative for the Thomson Electric Welding Company, in Europe where he successfully introduced this method of welding. Two years later he returned to this country, continuing his work at the Lynn Works of the General Electric Co. as Assistant to E. W. Rice, Jr., Technical Director of the company. In the course of the following years, he was promoted to Engineer of the Supply Department and Manager of the Lynn Works. In 1920 he resigned from the General Electric Company to identify himself with the International Electric Company with headquarters in Paris, but in 1922 he returned to this country to become Consulting Engineer to the General Electric Company, a service which involved many important developments in the foreign field as well as in this country. In 1924 he retired from active practise. Mr. Fish became an Associate of the Institute in 1891, was made a Fellow in 1913 and at his death was a Member for Life. He was also a member of the Boston Engineers Club, and other technical societies.

Charles Thomas Wright, Electrical Foreman of Stevens & Wood, Inc., Youngstown, Ohio, and an Associate of the Institute since 1926, died August 15, 1929 at his residence in that city. He was born at Shinnston, West Virginia, in 1894, and by profession and practise, was an electrical engineer. During the year 1918 he was identified with the Firestone Tire and Rubber Company at Akron, Ohio, but left that position in 1919 to become Testing Engineer in charge of instrument calibration, installation and maintenance for the Youngstown Sheet and Tube

Company, at Youngstown, Ohio. He remained with them a year and in 1921 joined the Babcock and Wilcox Boiler Company, at Barberton, Ohio, as Estimating Engineer. In 1922 he became affiliated with Stevens and Wood, Inc., in 1923 holding the position of Foreman of Electrical Construction of the Toronto Power Station in charge of very important work, both there and at the Lowellville Power Station. In 1925 he was made Chief Electrician of the Toronto Station for the Pennsylvania-Ohio Power & Light Co., constructing, testing and placing in successful operation a large steam turbine plant.

Albert E. Walden, Consulting Engineer who died August 26, 1929 at his home in New York City, was born at Rockland, Maine, August 18, 1872. He was educated in public school, intermediate grammar and business college course, with evening instruction in electrical engineering at Wesleyan University. His first position was as a water boy with a pipe laying contractor; later, a helper in a tramway hoisting and electric light and gas works during vacation periods. In 1888 the Rockland & Thomaston Gas & Electric Light Company engaged him for work in the engine-room of the electric light plant and gas works, where, until 1890, he was in charge of operation of the plant. For six months he was with the Edison Company on the construction of the Rockland, Thomaston & Camden Street Railway Company in the installation of engines, generators, tracks, lines, car wiring, motors, etc.; another six months were spent with the Schuyler Electric Works in the arc lamp, meter, armature and electric welding department. From 1891 to 1892 he was Superintendent for the Middletown Electric Light Company, at Middletown, Conn.; later he joined the Reynolds Engineering Company, of Hartford, Conn., as Superintendent in charge of the construction of lighting and power plants, motor installations, switchboard, wiring, and as Assistant Electrical Inspector. During the period from 1896 to 1906 he was successively superintendent for many representative electrical concerns, accomplishing important work for each in the irrespective fields of activity. From 1906 to 1921 he was with the Baltimore County Water and Electric Company as Chief Engineer and Purchasing Agent, working for the Mayor and City Council of Baltimore in the supervision of new constructions and consulting engineering. Finally he was appointed Chief Engineer and Executive for the Baltimore County Metropolitan District under the County Commissioners of Baltimore, where this field covered an area of some 200 square miles. Mr. Waldon joined the Institute as an Associate in 1908 and was transferred to the grade of Member in 1918. He was also a member of The American Society of Mechanical Engineers and other technical organizations.

A. I. E. E. Section Activities

FUTURE SECTION MEETINGS

NEW YORK BEGINS WITH GROUP IDEA IN OPERATION

The opening meetings of the new administrative year of the New York Section are scheduled for October 22nd and October 30th. The first meeting will be the regular general monthly meeting planned to be of interest to the entire Section although at the present time it is not possible to give details. These monthly meetings are to be continued just as in the past. And in addition, twelve group meetings are scheduled for this year. The expansion of Section Activities through the development of groups was completely outlined in the May 1929 JOURNAL, page 410. There will be four groups actively at work this year, as follows: Power, Communication, Illumination, and Transportation. A majority of the group meetings will be held in the small auditorium on the 5th floor of the Engineering Societies Building, New York; however, there are several planned for other locations. A complete schedule follows. In all probability it will be necessary to make some changes in the dates listed during the year, but notice of such changes will appear in the JOURNAL and by special notice to New York Section members.

SCHEDULE OF NEW YORK SECTION MEETINGS

GENERAL AND GROUP MEETINGS

Tuesday, October 22, 1929, General Monthly, Auditorium, Engineering Societies Building.

Wednesday, October 30, 1929, Power Group, Room 1, Fifth Floor, Engineering Societies Building.

Monday, November 4, 1929, Transportation Group, Fifth Floor, Engineering Societies Building.

Friday, November 8, 1929, General Monthly, Auditorium, Engineering Societies Building.

Wednesday, November 13, 1929, Communication Group, Room 2, Fifth Floor, Engineering Societies Building.

Monday, December 9, 1929, Power Group, Room 2, Fifth Floor, Engineering Societies Building.

Friday, December 18, 1929, General Monthly, Westinghouse Lighting Institute Building.

Tuesday, January 7, 1930, Illumination Group, Room 2, Fifth Engineering Societies Building.

Monday, January 13, 1930, Transportation Group, Room 2, Fifth Floor, Engineering Societies Building.

January 27-31, 1930, Winter Convention.

Wednesday, February 19, 1930, Communication Group, 140 West Street, New York Telephone Building.

Friday, February 28, 1930, General Monthly, Auditorium, Engineering Societies Building.

Wednesday, March 11, 1930, Power Group, Newark, N. J.

Tuesday, March 18, 1930, Transportation Group, Room 2, Fifth Floor, Engineering Societies Building.

Friday, March 28, 1930, General Monthly, Auditorium, Engineering Societies Building.

Tuesday, April 8, 1930, Illumination Group, Room 2, Fifth Floor, Engineering Societies Building.

Friday, April 25, 1930, Student Branch Committee and General Monthly Meeting, Room 1 and Auditorium, Engineering Societies Building.

Wednesday, May 7, 1930, Communication Group, Newark, N. J.

Tuesday, May 13, 1930, Power Group, Room 1, Fifth Floor, Engineering Societies Building.

Friday, May 23, 1930, General Monthly, Auditorium, Engineering Societies Building.

A glance at the preceding schedule will be evidence that the New York Section is going to provide ample opportunity for its members to attend many meetings. The groups will devote themselves largely to subjects of a technical nature, and an effort will be made to encourage discussion, particularly by the younger engineers.

Erie

October 24. *Lightning Problems* by H. M. Towne, Pittsfield Works, General Electric Company.

Madison

October 9. Dinner at Wisconsin Memorial Union Building. Professor Edward Bennett, main speaker. Subject: *The Inadequacy of the Public Utilities Law of Wisconsin.*

October 21. Celebration, "Light's Golden Jubilee."

November 29. Dinner—Speaker: Professor Harold B. Smith, President. Subject: *The Quest of the Unknown,* a summary of 35 years' adventures in high voltages. Slides.

St. Louis

Wednesday, October 16. Social meeting in celebration of "Light's Golden Jubilee."

PAST SECTION MEETINGS

Birmingham

Adoption of by-laws. Election of members of the Executive Committee as follows: J. M. Barry, W. E. Bare, W. W. Ballew. A report of the Summer Convention at Swampscott was given by H. M. Woodward, Delegate of the Section to that Convention. W. W. Ballew gave a brief talk on his experiences in other Sections of the A. I. E. E. The meeting was preceded by a luncheon. August 2. Attendance 26.

Louisville

A meeting in the form of a lawn party at the home of James Clark, Jr. Reports of several committees were presented. *Reminiscences of the Electrical Industry Since* 1880, by James Clark, Jr., of the James Clark, Jr. Electric Company. Refreshments were served. July 22. Attendance 34.

Minnesota

Professor W. T. Ryan, Vice-President, Great Lakes District, spoke upon the Institute activities in the District. *New Methods in the Manufacture of Electrical Machinery*, by J. M. Bryant, University of Minnseota. A dinner preceded the meeting. The results of the election of officers for 1929-30 were announced as follows: V. E. Engquist, Chairman; D. K. Lewis, Vice-Chairman; Oscar Gaarden, Secretary-Treasurer;—Executive Committee: J. C. Vincent, J. B. Hecht, Andrew Nelson. May 27. Attendance 25.

Dinner Dance. June 5. Attendance 84.

Nebraska

Election of officers as follows: D. H. Braymer, Chairman; O. E. Edison, Vice-Chairman; W. O. Jacobi, Secretary-Treasurer. The Secretary-Treasurer reported that since August 1, 1828, the Section had secured 21 new members and lost only 4 members. L. F. Wood, Delegate of the Section to the Summer Convention, reported upon the activities at that Convention. July 9. Attendance 10.

Seattle

The Quest of the Unknown, by Harold B. Smith, President A. I. E. E.; illustrated with lantern slides. President Smith also gave a brief talk on Institute activities. The personnel of committees was announced. G. E. Quinan, Vice-President, North West District gave a brief talk upon Institute activities in that District. August 22. Attendance 49.

Spokane

The Quest of the Unknown, by Harold B. Smith. President A. I. E. E. After the meeting, President Smith was the guest of honor at a luncheon and spoke upon the activities of the Institute. August 26. Attendance 15.

Toledo

Dinner meeting at Toledo Yacht Club. The following officers were elected: E. B. Featherstone, Chairman; F. H. Dubs, Vice-Chairman; Max Neuber, Secretary-Treasurer; Fred E. Helwig, Membership Committee. Executive Committee; O. F. Rabbe, T. J. Nolan, W. E. Salber. Brief talks were given by the newly elected officers and E. B. Featherstone, Chairman-elect, gave a talk on the past and present of radio. June 13. Attendance 25.

A. I. E. E. Student Activities

STUDENT ACTIVITES AT PACIFIC COAST CONVENTION

Technical Sessions

During the Tuesday afternoon session at the Pacific Coast Convention held at the Miramar Hotel, Santa Monica, Calif., September 3-6, 1929, five papers by engineering students in the Pacific and North West Districts were presented. Doctor F. W. Maxstadt of the California Institute of Technology presided. In a brief address at the opening of the session, President Harold B. Smith emphasized the importance of the Branches and the benefits that may be received by the students, and described briefly the proposed plan for encouraging young men to become Associates immediately after graduation.

The following program was then presented:

Experience with a Cathode Ray Oscillograph in a College Laboratory, by Charles C. Lash, Graduate Student, California Institute of Technology.

Characteristics of Electrostatic Loud Speakers, by F. J. Somers and George Mattos, University of Santa Clara—(Presented by F. J. Somers).

High-Voltage Streamers and Gradients, by W. G. Hoover and Corbett McLean, Graduate Students, Stanford University—(Presented by Gordon Kimball, Stanford University).

Voltage Distribution on High-Tension Insulators, by Floyd Gowans and Ned Chapman, University of Utah—(Presented by Lorin Moore, University of Utah).

Voltage Amplification of the Screen Grid Tube as an Intermediate Frequency Amplifier, by Frank Giovanini, Graduate Student, University of Washington—(Presented by K. E. Hammer, University of Washington).

Professor P. S. Biegler, Counselor, University of Southern California Branch, presided at the Thursday morning session, at which the six Student papers named below were presented:

Influence of Rotor Impedance on the Starting Characteristics of Squirrel Cage Induction Motors, by Andrew V. Haeff, Graduate Student, California Institute of Technology.

The Heating of Copper Conductors by Transient Electric Currents, by S. O. Rice, Oregon State College—(Presented by B. G. Griffith, Oregon State College).

Study of the Losses in a 25,000-Kv-a. A-c. Generator, by J. G. Pleasants and M. Tucker, University of Southern California—(Presented by J. G. Pleasants).

The Operation of Synchronous Motors in Series, by Carl R. Koch, Graduate Student, Stanford University—(Presented by H. E. Hill, Stanford University).

Power Losses by Radiation from Domestic Hot Water Tanks, by R. D. Wailes, University of Washington—(Presented by Ernest Engle, University of Washington).

Cycle and Transient Illumination of Incandescent Lamps as Measured by the Photoelectric Cell, by Zed J. Atlee and Ralph W. Mize, Oregon State College—(Presented by B. G. Griffith, Oregon State College).

The papers at the two sessions were well presented, and some of them aroused a considerable amount of discussion by both students and practising engineers. The sessions were well attended by representatives of both groups.

Conference on Student Activities

Following the plan which has been in effect since approved by the Board of Directors in 1927, a joint Conference on Student Activities of the Pacific and North West Districts was held. Nearly all Branches in the two Districts were represented by their Counselors and Chairmen. The Conference which was opened after the technical session on Tuesday afternoon was continued at dinner and concluded by a session late Thursday afternoon. Professor J. C. Clark, Counselor, University of Arizona Branch presided.

The following program was presented:

The Student Branch as an Employment Agency, by Professor F. O. McMillan, Counselor, Oregon State College Branch.

Organization and Conduct of Branch Meetings, by Professor L. E. Reukema, Counselor, University of California Branch.

Maintenance of Interest in Student Branch Meetings, Professor T. H. Morgan, Counselor, Stanford University Branch.

Student Branch Membership, by Professor S. G. Palmer, Counselor, University of Nevada Branch.

Student Papers, by Professor J. C. Clark, Counselor, University of Arizona Branch.

The Duties of a Branch Counselor, by Henry H. Henline, Assistant National Secretary.

In Professor McMillan's report and extended discussion on this subject, the importance of establishing definite cooperative relations for the summer employment of engineering students was strongly emphasized. As a result of the recommendation made at the 1928 Conference on Student Activities at the Pacific Coast Convention in Spokane, a conference of the officers and Counselors of District No. 9 with the representatives of the larger companies held in the winter led to the employment during the past summer of a considerable number of students.

In the presentation of the other subjects and in the discussion that followed, considerable emphasis was placed by various speakers upon certain ideas connected with Branch work, notably the following: Branches offer excellent opportunities for the development of elements of leadership and therefore early and full participation should be encouraged; the interest of students comes naturally when they fully realize the functions of the Branches and the benefits received are proportional to the interest; forced methods are not effective as such activities must for best results depend upon voluntary effort; student papers bring out discussion to an extent not possible when programs are supplied by outside speakers; Counselors should assist the officers of the Branch by offering general advice and suggestions, but should carefully avoid reducing the prestige of these officers by assuming their responsibilities; joint Section and Branch meetings with student programs have been very successful in several locations in each of the two Districts.

Following the close of the Joint Conference on Student Activities, the Counselors of the two Districts met separately and elected chairmen of the respective committees on Student Activities for the current year as follows: Pacific District, Professor T. H. Morgan, Stanford University; North West District, Professor R. D. Sloan, State College of Washington.

BRANCH ORGANIZED AT MICHIGAN COLLEGE OF MINING AND TECHNOLOGY

At its meeting held on June 25, 1929, the Board of Directors authorized the formation of a Student Branch at the Michigan College of Mining and Technology, Houghton, Michigan. The Branch has organized and elected the officers named below:

Charles F. Sawyer, Chairman
Howard Kramer, Vice-Chairman
Berry G. Swart, Secretary and Treasurer

Professor G. W. Swenson has been appointed Counselor of the Branch.

PAST BRANCH MEETINGS

University of California

Business session. Dr. Reukema, Counselor of the Branch described his recent trip in the eastern part of the United States and in Europe. N. C. Clark, Student, gave a summary on experiences of the Branch inspection trips, illustrating his talk with lantern slides. August 22. Attendance 53.

Drexel Institute

Inspection trip to the Conowingo plant of the Philadelphia Electric Company. July 27. Attendance 23.

University of Louisville

Business meeting. General discussions on plans for making the Branch meetings interesting. July 11. Attendance 9.

Airplane Compass Problems, Robert Wyatt, Student, and *Instruments used by the Bureau of Standards*, Edward Sutt, Student. July 25. Attendance 10.

Effect of Heat on Commutation, by Alvin Smith, Student, and *The Oscillograph*, by Charles Habich, Student. Humorous readings entitled, *Lesson No. 1*, and *Portland Cement* were given by Professor John P. Jones. August 8. Attendance 19.

University of Pittsburgh

Election of officers for 1929-30 as follows: W. A. Aeberlie, Chairman; K. K. Ely, Vice-Chairman; G. L. Bolender, Secretary-Treasurer. May 10. Attendance 66.

Ninth annual banquet of the Branch held at the University Club, Pittsburgh. J. B. Luck, Chairman acted as toastmaster. The principal address was given by F. J. Chesterman, Vice-President and General Manager, Bell Telephone Company of Pittsburgh, and Director of the A. I. E. E. Other talks were given by Dean Holbrook of the School of Engineering, Professor H. E. Dyche, Counselor, J. R. Britton, Chairman of the Carnegie Institute of Technology Branch, and representatives of the four classes in electrical engineering at the University of Pittsburgh. May 22. Attendance 67.

University of Santa Clara

Business meeting. August 22. Attendance 29.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these Founder Societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES, AUGUST 1-31, 1929

Unless otherwise specified, books in this list have been presented by the publishers. The Societies do not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

ALUMINIUM, DIE LEICHTMETALLE UND IHRE LEGIERUNGEN.

By Paul Melchior; im auftrage der Deutschen Gesellschaft für Metallkunde. Berlin, V. D. I.-Verlag, 1929. 280 pp., illus., tables, diagrs., 8 x 6 in., cloth. 15.-r. m.

A handbook on aluminum and magnesium and their alloys, which aims particularly to meet the practical needs of engineers. The metallography, chemistry and physical properties of the

metals are described; methods of shaping, finishing and joining are explained; and the uses of the metals and alloys for various purposes are related. Standards of various countries are given. Much scattered scientific information is made conveniently accessible to machine builders.

AMERIKANISCHE KÄLTETECHNIK.

By R. Plank. Berlin, V. D. I. Verlag, 1929. 134 pp., illus., tables, diagrs., 8 x 6 in., cloth, 12.-r. m.

In this account of refrigeration engineering in America, the Director of the Refrigeration Institute at the Karlsruhe Technical High School describes modern refrigerating machines and their use for ice-making, for producing "dry ice," for cold storage plants and for cooling air. The data were collected during a visit to American plants in 1927.

DRUCKROHRLEITUNGEN DER WASSERKRAFTWERKE, ENTWURF, BERECHNUNG, BAU UND BETRIEB.

By Artur Hruschka. Wien, Springer, 1929. 283 pp., illus., tables, diagrs., 9 x 6 in., paper, 23.-r. m.

This book aims to review the theoretical and practical considerations that govern the design of high-pressure water conductors for power plants, the methods of construction that have become generally accepted, and some of the especially noteworthy pipe lines of the world. The book discusses the theory, design, and construction of pipe, pipe fittings and pipe lines, and the operation and maintenance of the latter fully and practically. A table of important lines is given, as well as an extensive bibliography.

ELEMENTS OF RADIO COMMUNICATION.

By John H. Morecroft. N. Y., John Wiley & Sons, 1929. 269 pp., illus., diagrs., 9 x 6 in., cloth. $3.00.

For students who wish something sounder and more thorough than popular texts, and who do not have the time or preparation for attempting such a text as the author's "Principles," Professor Morecroft has written this elementary work. It gives a general review of the necessary parts of alternating-current theory, followed by their specific applications to radio communication. One chapter is devoted to receiving sets. The book, the author says, is sufficiently complete for all radio enthusiasts except engineers specializing in that subject.

DIE ELEKTRIZITÄTSVERSORGUNG SOWJETRUSSLANDS.

By G. Dettmar. Berlin, Springer, 1929. 19 pp., illus., maps, diagrs., 12 x 8 in., paper, 2.40-r. m.

A pamphlet describing the present development of the electric power supply in Russia and the government plans for its development. Reprinted from the Elektrotechnische Zeitschrift.

EVAPORATING, CONDENSING AND COOLING APPARATUS.

By E. Hausbrand; trans. from 2nd rev. German ed. by A. C. Wright. 4th English ed. rev. and enl. by Basil Heastie. N. Y., Van Nostrand, 1929. Tables, diagrs., 9 x 6 in., cloth. $8.00.

In preparing this edition, the reviser has rewritten the chapters dealing with the flow of steam, water, and air through pipes, and has recalculated the tables in the light of recent experiments at the National Physical Laboratory. He also includes a summary of recent work on heat losses through convection and radiation, and has added a chapter on modern evaporating plants. These changes, with the thorough revision of the tables and general text, make the book of renewed value to designers of this apparatus, who will find here many formulas and tables of service.

FARM MACHINERY AND EQUIPMENT.

By Harris Pearson Smith. N. Y., McGraw-Hill Book Co., 1929. 448 pp., illus., tables, 9 x 6 in., cloth. $3.25.

After a brief introductory discussion of the principles of farm machinery, the various types of farm machines are described and their construction, operation, and efficiency discussed. The entire field of American usage is covered.

KABELTECHNIK.

By M. Klein. Berlin, Julius Springer, 1929. 486 pp., illus., diagrs., tables, 9 x 6 in., cloth. 57.-r. m.

Covers quite thoroughly the manufacture of electric cables for heavy and light currents. Materials, design, methods of manufacture and testing, cable laying and connecting are treated, together with the underlying theory. The most complete modern account in print.

RAILWAY ENGINEERING AND MAINTENANCE CYCLOPEDIA.

Ed. 3, edit. by Elmer T. Howson. N. Y., Simmons-Boardman Publ. Co., 1929. 1116 pp., illus., plates, diagrs., 12 x 9 in., cloth. $7.00.

This well-known manual of American railroad practise covers the construction and maintenance of the fixed property. Track, bridges, buildings, water service, and signaling are covered, attention being given to the materials used, the processes of construction and operation, and the equipment employed. Correct definitions of terms are given, and the latest standard specifications.

SIR JOSEPH WILSON SWAN, F. R. S., a Memoir, by M. E. S. and K. R. S. London, Benn (1929). 183 pp., plate, portraits, 8 x 6 in., cloth. 7/6.

An unusually well written biography. Swan's inventions in photography, electric lighting and artificial silk are described, and a careful attempt made to define accurately his contributions in these fields. His minor inventions are also recorded.

STATICS, including Hydrostatics and the Elements of the Theory of Elasticity.

By Horace Lamb. 3rd edition. Cambridge, University Press, 1928. N. Y., Macmillan Co. 357 pp., 9 x 6 in., cloth. 12s 6d; $4.25.

Professor Lamb's text, based upon his course at the University of Manchester, is distinguished by its easy mathematical style and its lucid presentation of the subject. Prominence is given to geometrical methods, particularly those of graphic statics. The new edition has been revised and partly rewritten.

STORY OF THE BALTIMORE & OHIO RAILROAD, 1827-1927.

By Edward Hungerford. N. Y., Putnam, 1928. 2 v., 372 + 365 pp., illus., portraits, facsims. 9 x 7 in., cloth. $10.00.

Tells in attractive fashion the history of the road from its inception in 1827 to the present time. The part played by the road in the development of the locomotive and the evolution of railroad practise, its economic influence in the development of the West, and its effect on the growth of Baltimore are well brought out, while the varying fortunes of the road are carefully portrayed. A valuable addition to railroad history.

UBER DEN STRÖMUNGSVERLUST IN GEKRÜMMTEN KÄNALEN (Forschungsarbeiten auf dem Gebeite des Ingenieurwesens. heft 320).

By H. Nippert. Berlin, V. D. I. Verlag, 1929. 67 pp., illus., diagrs., 12 x 8 in., paper, 9.-r. m.

With the support of various German engineering and physical societies and firms, the author has made an extensive investigation of the flow of water in curved pipes and channels. He reviews previous investigations of stream flow and losses in bends, describes the various factors that determine them, and investigates very fully the effect of certain of these factors by careful experiments. The results are given in graphic charts and in photographs of flow in open channels.

WIRTSCHAFTSFUHRUNG UND FINANZWESEN BEI AMERIKANISCHEN EISENBAHNEN; eine Studie, by Ludwig Homberger.

Berlin, Verlag der Verkehrswissenschaftlichen Lehrmittelgesellschaft, 1929. 103 pp., 8 x 7 in., paper, 4.80 r. m.

A description of railroad organization, finance and accounting practise in America, by a director of the German Railroad Company, based upon first-hand study and observation.

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contribution from the societies and their individual members who are directly benefited.
Offices:—31 West 39th St., New York, N. Y.,—W V. Brown, Manager.
1216 Engineering Bldg., 205 W. Wacker Drive, Chicago, Ill., A. K. Krauser, Manager.
57 Post St., San Francisco, Calif., N. D. Cook, Manager.

MEN AVAILABLE.—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to ***EMPLOYMENT SERVICE, 31 WEST 39th Street, New York City****, and should be received prior to the 15th day of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary: temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

POSITIONS OPEN

ELECTRICAL ENGINEER, preferably with post graduate schooling in the electrical branches of physics and a few years' experience in industrial research or development, for development and research work with a growing firm in varied fields embracing control apparatus and vacuum tube applications. Apply by letter. Location, New England. X-9387.

ELECTRICAL ENGINEER, who has had broad experience in connection with the design and developing of condenser fractional horse power. Apply by letter stating age, training, and practical experience. Location, Middle West. X-9442.

ELECTRICAL ENGINEER, with one to four years' general experience for work on underground cable research, reports and allied problems. Apply by letter giving in detail experience, age, and salary expected. Location, Middle West. X-9455-C.

ELECTRICAL ENGINEER, with one to four years' experience for design and test work on underground power cables and accessories over a large range of voltages. Any type of design or testing experience desirable. Apply by letter giving age, experience in detail, and salary expected. Location, Middle West. X-9456-C.

GRADUATE ELECTRICAL ENGINEER, as sales engineer; products are insulating varnishes and compounds, and it is necessary for representatives to be well versed in the electrical fundamentals. Will be constantly coming in contact with electrical engineers of electrical manufacturing concerns, electrical men of the street railways, large industrials, and the commercial electric repair shops through the country. Apply by letter. Salary about $35 a week. Location, New Jersey. X-9344.

DESIGNING ENGINEER, having experience with large electrical manufacturing firm and able to independently design electrical machines of over 10,000 kw. Apply by letter. Location, Europe. X-9244-CS.

ELECTRICAL ENGINEERS, young, recent graduates who have had good scholastic standing and experience in engineering, construction, and operation, or the manufacture of equipment for power companies. Capable of doing general engineering and station design work. Apply by letter. Location, Middle West. X-8546-C.

MEN AVAILABLE

ELECTRICAL ENGINEER, 36, college graduate, 15 years' experience in design construction and operation of hydraulic power plants in Latin America. Four years superintendent and district manager. Speaks fluently, Spanish and French. Personality. Available on short notice; foreign countries preferred. B-8593.

AMERICAN. Six years sales engineer covering U. S. and Canada. Nine years present position business executive spending most of time in foreign lands. Age 39, married, steady, good health, enjoys work. Personality that wears, thorough sales and business training. Handles French correctly. Seeks sales engineering or export connection with reliable company. Location, immaterial. Now on Pacific Coast. C-5817.

GRADUATE, Electrical Engineer, wide experience in construction, operation, maintenance, generating, transmission at 100,000 volts, underground transmission 6600 and 2200 volts, outdoor and indoor substations, mill installations. Has had sales and managing experience in Latin America and India. Speaks English, Spanish, German, French, and Hindustani. Location, immaterial. Now employed. C-4222.

ELECTRICAL AND STEAM ENGINEER, 30, married, 1923 graduate Electrical Engineer. Ten years' practical experience in design, construction, operation and maintenance of generating, transforming, and transmission systems, rewinding and reconnecting a-c. and d-c. motors. Government steam license. Speaks technical Spanish. Now employed. Location desired, South, West, or foreign. C-6295.

ELECTRICAL ENGINEER, 37, college graduate, fourteen years' experience in substation and powerhouse design, construction and maintenance. Last six years superintendent of construction and maintenance, for a large public utility on superpower expansion. Desires permanent position as construction superintendent with large holding company or industry. C-748.

ENGINEER, 31, single, with exceptional education and technical training, desires permanent position. Diversified engineering experience. Analytical, development, testing, or research work preferred; work need not be of strictly technical sort, however, if of sound potential value and conducive to individual development. Opportunities for advancement of primary importance. Location, East. C-6345.

RESEARCH ENGINEER, 45, 10 years in charge of design and construction scientific instruments for research work in terrestrial magnetism. Two years' experimental work on gyrocompasses; nine years charge of research work and later promoted to chief engineer in electrical concern manufacturing enclosed switches, magnetic switches, panel boards, and other control apparatus. West or South preferred. C-6362.

ELECTRICAL ENGINEER, 20 years' experience on construction work, design and appraisals, as foreman and engineer in charge. At present employed as construction engineer. Available on short notice. Best of references. C-6347.

ELECTRICAL ENGINEER, 35, married, with technical, business management and accounting training. Twelve years with large public utilities. Experienced on meters, instruments and relays, test maintenance, operation, blueprint, and station control wire checking. Interested in hydroelectric developments automatic substations and automatic meter test boards. C-6320.

ELECTRICAL ENGINEER, 33, married, B. S. in Electrical Engineering; 1½ years G. E. Test; 8 years' experience with public utilities covering construction, estimating, design and general engineering on steam and hydro power stations, indoor and outdoor substations up to 220 kv. East preferred. B-8231.

SALES ENGINEERING EXECUTIVE, available October, November. Electrical Engineer, age 30, single. Successful record as general sales manager and sales engineering specialist. Development ability with knowledge of circuits and applications of small electrical equipment in principal industries. Location immaterial, free for unlimited traveling and difficult assignments. B-7924.

ELECTRICAL AND MECHANICAL ENGINEER, 31, graduate, seven years' wide experience in design, maintenance, construction, and application of equipment with public utility, steel mill, and manufacture, desires position as chief engineer, plant engineer, or otherwise in an executive capacity. Thoroughly familiar with both electrical and mechanical ends. At present in charge of responsible work. C-1297.

ENGINEERING GRADUATE, Cornell 1922 E. E. Degree, desires position, mechanical or electrical engineer, preferably with consulting firm. Experience, one year university instructor, five years professor of Electrical Engineering, two years chief engineer of gypsum company; assisted in design and now erecting wallboard plant in England. Location preferred, California. C-6403.

A-C. AND D-C. DESIGNER, technical graduate, age 33, married, 9 years' unusually broad experience in the design of electrical machinery. Has initiative and is resourceful. Wishes similar position with manufacturer of electrical machinery. C-6387.

ELECTRICAL ENGINEER, 25, married, 1929 graduate, in practise four years between junior and senior years. Two years designing and installing municipal electrical improvements, and

developing engineering advertising literature, besides public utility experience totaling four years. Aptitude for charts and statistics. Good draftsman. Now employed. Desires greater responsibility. Location, immaterial. C-6381.

1926 GRADUATE, 26, unmarried, with three years' varied experience in railway signal manufacturing organization desires work in Washington, D. C., in engineering department, either electrical or industrial; or patent department of a progressive organization. Objective is study of patent law. Rate of remuneration not vitally important for few years. C-6372.

ELECTRICAL ENGINEER, university graduate, 40, wide knowledge of electrification including hydroelectric generation, substation distribution, motor application, lighting and electric furnaces. Experience covers estimates, design and layout, construction, operation and maintenance. Desires position with power company or industry in engineering or operating divisions. B-645.

1929 GRADUATE, electrical engineering, desires position which requires some application of engineering principles, and does not consist of routine work. Three months' experience in power distribution work with large power company. New York City preferred as location, but willing to travel, or locate elsewhere. Not interested in sales jobs. C-6408.

ELECTRICAL ENGINEER, 39, single, 12 years' experience including central station design, equipment manufacture and test expert on control systems. Location preferred, New York. C-3905.

ELECTRICAL DRAFTSMAN, age 35, twelve years designing and engineering experience on line of service switches, molded insulations, meter test devices catenary suspension material, etc. Three years sales work and experimental radio experience. Available immediately for position in Connecticut or Massachusetts. Reasonable salary with opportunity for advancement. C-6430.

GRADUATE ELECTRICAL ENGINEER, 1929, with transmission and distribution experience; also trouble shooter with public utility. C-6434.

ELECTRICAL ENGINEER, 24, single, 1928 graduate, desires work of more electrical nature. Interested in using training not only at purely technical work, but as foundation for promotion of good will; education of consumer; technical sales, service, etc. One year industrial experience. Available thirty days' notice. C-4905.

CIVIL AND HYDROELECTRIC ENGINEER, age 37, extensive experience in hydroelectric developments, steam power plants, hydraulic structures, etc. Late engagement as chief engineer large hydro development on design and construction. Capable executive wants responsible position. C-6336.

RECENT GRADUATE, Electrical Engineering 1928, 24, married, desires opportunity with public utility or industrial concern in commercial or sales work preferably as head of illuminating department. Has done special work in illumination engineering and has been with public utility as statistician since July 1, 1928. Location, United States. C-6446.

ELECTRICAL ENGINEER, American, 38, married. Speaks Spanish. Recently returned from South America. Experienced in organization, management of departments, estimate design, layout, construction, operation, maintenance, repair of electrical and mechanical equipment used in generating stations, substations, industrial plants. As chief engineer or manager for small public utility. Location, immaterial. Available reasonable notice. C-502.

MEMBERSHIP—Applications, Elections, Transfers, Etc.

RECOMMENDED FOR TRANSFER

The Board of Examiners, at its meeting of September 25, 1929, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grade of Fellow

BERRY, EDWARD R., Consulting Engineer, General Electric Co., West Lynn, Mass.
FAHY, FRANK P., Consulting Engineer, New York, N. Y.
FIELDS, Manager, Elec. Dept., Union Gas & Elec. Co., Cincinnati, Ohio.
KEENAN, GEORGE M., Supt.-Pa.-New Jersey Interconnection-Public Service Elec. & Gas Co.; The Philadelphia Elec. Co.; Penn. Power & Light Co., Hazleton, Pa.
LARSEN, CHRISTIAN J., Consulting Engineer, Associated Tel. & Tel. Co., Chicago, Ill.
SHREEVE, HERBERT E., Technical Representative in Europe, American Tel. & Tel. Co. and Bell Laboratories, London, England.
STOKES, STANLEY, Asst. Vice-President and Power Supervisor, Union Elec. Lt. & Pr. Co., St. Louis, Mo.

To the Grade of Member

ALTHOUSE, ADAM J., Asst. General Manager, Metropolitan Edison Co., Reading, Pa.
BESSEY, CARL A., Research Engineer, Byllesby Engg. & Mgt. Corp., Chicago, Ill.
BRIGGS, WALLACE W., Vice-President and General Manager, Grays Harbor Ry. & Lt. Co., Aberdeen, Wash.
CARNEY, JOHN T., Long Lines Engg. Dept., American Tel. & Tel. Co., New York, N. Y.
DEAN, HARVEY C., Distribution Engineer, Yonkers Elec. Lt. & Pr. Co., Yonkers, N. Y.
DENTON, CHARLES F., Power Corp. of Canada, Montreal, Canada.
EARLE, R. H., Engineer, Allis-Chalmers Mfg. Co., Milwaukee, Wis.
EVENSON, FRANKLIN F., Consulting Engineer, San Diego, Calif.
GARRISON, FRED, Commercial Engineer, General Electric Co., Los Angeles, Calif.
GLEZEN, LEE L., Telephone Engineer, American Tel. & Tel. Co., New York, N. Y.
HALE, JOHN C., Electrical Engineer, Research Corporation, Bound Brook, N. J.
HUNTLEY, H. R., Transmission Engineer, Wisconsin Telephone Co., Milwaukee, Wis.
JONES, LAURENCE D., Designing Engineer, General Electric Co., Schenectady, N. Y.
KERR, E. M., Illumination Engineer, Pacific States Elec. Co., Portland, Ore.
KVAAL, ANDREW B., Member of Technical Staff, Bell Telephone Laboratories, New York, N. Y.
MILLER, JAMES S., Associate Prof. of Elec. Engg., University of Virginia, University, Va.
MOTT, HAROLD E., Manager, Engg. and Production, Standard Radio Mfg. Corp., Toronto, Ont., Can.
NICKEL, LEONARD W., District Manager, *Electrical World* and *Electrical West*, Cleveland, Ohio.
PALUEFF, K. K., Research Engineer, General Electric Co., Pittsfield, Mass.
PARTRIDGE, WARREN, Vice-President, Utility Companies with J. G. White Engg. Corp., New York, N. Y.
RICHARDSON, J. A., Electrical Engineer, Westinghouse Elec. & Mfg. Co., Sharon, Pa.
ROSENBACH, SAMUEL, District Distribution Engineer, Byllesby Engg. & Mgt. Corp., Pittsburgh, Pa.
SHANE, ADOLPH, Professor of Industrial Arts, Iowa State College, Ames, Iowa.
SHETZLINE, ROY A., Engineer, American Tel. & Tel. Co., New York, N. Y.
SPEER, J. L. DAWSON, Transmission and Protection Engineer, Chesapeake & Potomac Telephone Co. of Baltimore City, Baltimore, Md.
TUSKA, CLARENCE D., Radio Engineer, Atwater Kent Mfg. Co., Philadelphia, Pa.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before October 31, 1929.

Baines, H. A., New England Power Co., Boston, Mass.
Birdwell, C. T., Louisville Gas & Electric Co., Louisville, Ky.
Bomgardner, P. E., Sr., General Engineering Co., Inc., Reading, Pa.
Brandle, F. J., Southwestern Bell Telephone Co., St. Louis, Mo.
Calmus, F. A., Elliott Co. of Calif., San Francisco, Calif.
Campbell, C. H., National Broadcasting Co., New York, N. Y.
Casiraghi, P. J., Postal Telegraph Cable Co., New York, N. Y.
Church, E. A., Edison Electric Illuminating Co. of Boston, Boston, Mass.
Cornish, A. H., Otis Elevator Co., New York, N. Y.
Day, J. F., Clines Inc., Washington, D. C.
DeVivo, T. A., Westinghouse Elec. & Mfg. Co., Newark, N. J.
Draper, L. L., Dept. of Water & Power, Los Angeles, Calif.
Eales, H. E., Los Angeles Gas & Electric Corp., Los Angeles, Calif.
Gale, L. J., New York Edison Co., New York, N. Y.
Garratt, W. E., Stevens & Wood, Inc., Jackson, Mich.
Gortorf, W. S., (Member), Bell Telephone Laboratories, New York, N. Y.
Harper, P. F., Pacific Tel. & Tel. Co., Los Angeles, Calif.
Hathaway, C. M., General Electric Co., Schenectady, N. Y.
Hawkins, G. S., Stomberg-Carlson Telephone Mfg. Co., Rochester, N. Y.
Hopkins, T. J., Graybar Electric Co., Inc., Reading, Pa.
Hutcheson, L. D., Aluminum Co. of America, Pittsburgh, Pa.
King, E. S., (Member), Kansas City Water Dept., Kansas City, Mo.
Kingston, R. L., Mineral County Power System, U. S. Naval Ammunition Depot, Hawthorne, Nev.
MacKenzie, W. A., New York Edison Co., New York, N. Y.
Martin, S. T., Jr., General Electric Co., Pittsfield, Mass.
McElroy, C. H., Los Angeles Gas & Electric Corp., Los Angeles, Calif.
Mixter, R. M., General Electric Co., Philadelphia, Pa.
Moller, N. S., Gibbs & Hill Co., New York, N. Y.
Morgan, A., Western Electric Co., Inc., Kearny, N. J.
Naudascher, W. H., Graybar Electric Co., Reading, Pa.

Parsons, F. M., Central West Public Service Co., Omaha, Nebr.
Peterson, A., Central West Public Service Co., Omaha, Nebr.
Rogge, H. H., (Member), Westinghouse Elec. & Mfg. Co., New York, N. Y.
Ryan, J. A., Public Service Commission of New York State, New York, N. Y.
Salowitts, L. W., S. S. Electric Construction Co., Roxbury, Mass.
Sawvel, J. S., The Toledo Bowling Green and Southern Traction Co., Findlay, Ohio
Smith, V. P., Eastern Mass. St. Railway Co., Fall River, Mass.
Stanton, A. N., Geophysical Research Corp., Tulsa, Okla.
Stoll, C. C., 3601 Grantley Road, Baltimore, Md.
Streicher, W., 1350 Madison Ave., New York, N. Y.
Washburn, A. E., Washington Water Power Co., Chelan Falls, Wash.
Wegrin, J. W., Amtorg Trading Corp., New York, N. Y.
Welch, E. R., Howard University, Washington, D. C.
Wells, H. B., Los Angeles Gas & Electric Corp., Los Angeles, Calif.
Winner, L., Hammarlund Mfg. Co., New York, N. Y.
Zerfass, H. P., J. H. Mencke & E. F. Abell, New York, N. Y.
Total 46.

Foreign

Adams, A. J., Oahu Sugar Plantation Co., Waipuhu, Oahu, Hawaii
Alderman, J. T., Messrs., Oki Electric Co. Ltd., Shibaura, Shiba-ku, Tokyo, Japan
Ayyar, A. V. D., Kanadukathan Electric Supply Corp., Ltd., Kanadukathan, Madras Presidency, So. India
Bernard, A. A., Chinna Bazzar Road, Guntur, South India
Da Costa, F. B. V., (Member), Sao Paulo Tramway, Light & Power Co., Sao Paulo, Brazil, So. America
Gelbke, A. W., So. American Development Co., Guayaquil, Ecuador, So. America
Kashyap, H. L., Public Works Department Hydro-Electric Branch, Lahore, Punjab, India
Kraemer, G. I., G. I. Kraemer, Asnieres, Seine, France
Mathur, B. S., Public Works Dept., Government of Punjab, Balawalnagar, Punjab, India
Middleton, E. W., (Member), Cia de Electricidad de la Provincia Junin & San Luis, Junin, F. C. P., Argentina, So. America
Okamoto, S., Yamanashi Higher Technical College, Kofu, Japan
Sibou, B. K., (Member), Hydroelectric Branch, Punjab P. W. D., Lahore, India
Wyse, M. N., (Member), International General Electric Co., Inc., Karachi, India
Yoshida, T., 798 Ikebukuro, Tokyo, Japan
Total 14

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(A list of the personnel of Institute committees may be found in the September issue of the Journal.)

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Transportation, Sidney Withington

A. I. E. E. REPRESENTATION

(The Institute is represented on the following bodies; the names of the representatives may be found in the September issue of the Journal.)

Alfred Noble Prize Committee, A. S. C. E.
American Association for the Advancement of Science, Council
American Bureau of Welding
American Committee on Electrolysis
American Engineering Council Assembly
American Marine Standards Committee
American Standards Association
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National Fire Waste Council
National Research Council, Engineering Division
National Safety Council, Electrical Committee of A. S. S. E.—Engineering Section
The Newcomen Society
Radio Advisory Committee, Bureau of Standards
Society for the Promotion of Engineering Education, Board of Investigation and Coordination
U. S. National Committee of the International Commission on Illumination
U. S. National Committee of the International Electrotechnical Commission
Washington Award, Commission of

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Boston	W. H. Colburn	G. J. Crowdes, Simplex Wire & Cable Co., Sidney St., Cambridge, Mass.
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Lehigh Valley	A. J. Althouse	E. F. Weaver, Pa. Pr. & Lt. Co., 901 Hamilton St., Allentown, Pa.
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Louisville	H. W. Wischmeyer	Philip P. Ash, Louisville & Nashville Rd. Bldg., 9th & B'way Ave., Louisville, Ky.
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Milwaukee	E. W. Seeger	R. C. Siegel, Wisconsin Tel. Co. 418 Broadway, Milwaukee, Wis.
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Panama		
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Pittsburgh	J. A. Cadwallader	C. T. Sinclair, Byllesby Engg. & Mngmt. Corp., 435 Sixth Ave., Pittsburgh, Pa.
Pittsfield	L. F. Blume	L. H. Burnham, General Electric Co., Pittsfield, Mass.
Portland, Ore	H. H. Cake	A. H. Kreul, Portland Elec. Pr. Co., Hawthorne Bldg., Portland, Ore.
Providence	F. W. Smith	O. W. Briden, Blackstone Valley Gas & Elec. Co., Pawtucket, R. I.
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St. Louis	G. H. Quermann	O. J. Rotty, Union Elec. Lt. & Pr. Co., 315 No. 12th Blvd., St. Louis, Mo.
San Francisco	L. F. Fuller	G. Ross Henninger, Electrical West, 883 Mission St., San Francisco, Cal.
Saskatchewan	J. R. Cowley	A. B. Coward, Light & Power Dept., Regina, Sask., Canada
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Springfield, Mass.	Fred L. Hunt	B. V. K. French, American Bosch Magneto Corp., Springfield, Mass.
Syracuse		F. E. Verdin, 1206 Hills Bldg., Syracuse, N. Y.
Toledo	E. B. Featherstone	Max Neuber, 1257 Fernwood Ave., Toledo, O.
Toronto	F. F. Ambuhl	W. F. Sutherland, Toronto Hydroelec. Sys., 225 Yonge St., Toronto, Ont., Canada
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Utah	A. C. Kelm	L. B. Fuller, Utah Pr. & Lt. Co., Salt Lake City, Utah
Vancouver	J. Teasdale	D. Robertson, Canadian Gen. Elec. Co., Ltd., Vancouver, B. C., Canada
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Worcester	H. H. Newell	R. P. Bullen, General Elec. Co., 704 State Mutual Bldg., Worcester, Mass.
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Photometers.—Catalog 60, 20 pp. Describes L & N photometric apparatus for the measurement of illumination and brightness, and of reflection and other factors that affect the distribution of light. Leeds & Northrup Company, 4901 Stenton Avenue, Philadelphia, Penn.

Tungsten and Other Metals.—Bulletin, 56 pp., entitled "Rare Metals." Describes the production of tantalum, tungsten and molybdenum, numerous applications and possible further uses. An interesting account of the origin of these rare metals and their development is included. Fansteel Products Company, Inc., North Chicago, Ill.

Generator Field Temperature Recorders.—Bulletin 871-A, 8 pp., on "Temperature Measurements in Generator Rotating Fields." Describes the L & N generator field temperature recorder for giving a continuous record of the temperature of the winding of a rotating field. Leeds & Northrup Company, 4901 Stenton Avenue, Philadelphia, Penn.

Potentiometer.—Bulletin 765, 20 pp. Describes the Students' potentiometer. This instrument has been designed for teaching the potentiometer principle and for making measurements which will emphasize the advantages of the potentiometer method. Leeds & Northrup Company, 4901 Stenton Avenue, Philadelphia, Penn.

Ammeters.—Bulletin 810, 4 pp. Describes Roller-Smith types TW, FW and STW thermocouple ammeters and milliammeters for direct current and alternating current of all frequencies, including radio frequencies. These instruments incorporate a new and improved form of thermocouple of very high overload capacity and sustained accuracy over a wide range of temperature. Roller-Smith Company, 12 Park Place, New York.

Contact-Cable.—Bulletin, 4 pp. Describes the "Nagy" contact-cable. Besides performing the function of an ordinary cable, that of leading electric current, this new conductor makes connection by pressure anywhere along its length, without pushbutton or switch. Applications suggested include installations in buses, street cars, etc., in industries where instantaneous stop of machinery is often desirable, for alarms, etc. The Bishop Wire & Cable Corporation, of New York, is the manufacturer and distributor of the new cable. Contact Cable Corporation, 420 Lexington Avenue, New York.

Kelvin Bridge.—Notebook No. 4, 36 pp. The chief purpose of this notebook is to provide information that will be of assistance in the operation of a Kelvin bridge. The fundamental principles of the Kelvin bridge method for measuring low resistance are first explained, and then follows a discussion of several types of Kelvin bridge suitable for different applications of the method. Leeds & Northrup Company, 4901 Stenton Avenue, Philadelphia, Penn.

Motor Generator Sets.—Bulletin 20-301, 4 pp. Describes two-bearing and four-bearing types of motor generator sets in sizes from ¼ to 100 kw. Applications include constant potential or constant current storage battery chargers, radio broadcasting, signal systems, electroplating, emergency lighting equipment, welding equipment, etc. Roth Bros. & Company (Division of Century Electric Company) 1400 W. Adams Street, Chicago, Ill.

Airport Lighting.—Bulletin S. P. 1854, 12 pp. Describes Westinghouse lighting equipment for illumination of airports. Included in the publication are the lighting requirements of the U. S. Department of Commerce, the candlepower for beacons, wattage for boundary lights, obstruction light requirements, and the location and intensity of illumination of floodlights and ceiling projectors. Westinghouse Electric & Mfg. Company, East Pittsburgh, Penn.

Motors.—Bulletin 165, 22 pp. Describes seven types of squirrel cage motors under the headings of general purpose, normal torque across-the-line, low torque across-the-line, high torque double squirrel cage, punch press and elevator types. The bulletin is, in the words of the authors, "the first attempt on the part of a motor manufacturer to explain to motor buyers and users the difference between the various types of squirrel cage motors." It is, in fact, a short text book, destined to minimize motor-misapplication in industry. Wagner Electric Corporation, 6400 Plymouth Avenue, St. Louis, Mo.

Power Cable.—Bulletin, 6 pp. Describes a unique underground installation of American Steel & Wire Company triple sheathed power cable for the Tennessee Coal, Iron and Railroad Company at Birmingham. The salient features contributing to high over-all efficiency of transmission are the comparatively high voltage (44 kv.) used for transmission; elimination of conduit and manholes; joints and reservoirs reduced two-thirds; sheath current losses negligible; low initial installation costs. Since the completion of this work early in 1928 the three circuits, consisting of approximately two miles of cable, have operated most satisfactorily. American Steel & Wire Company, 208 So. LaSalle Street, Chicago, Ill.

NOTES OF THE INDUSTRY

Wagner Electric Personnel Changes.—Announcement has been made by the Wagner Electric Corporation, St. Louis, that James G. Pattillo, Jr., has been appointed manager of the Pittsburgh branch sales office. J. B. Holston has been made branch manager of the St. Louis sales office. A new branch sales office at 734 Allen Building, Dallas, Texas, has been opened and Alfred B. Emrick has been placed in charge as manager.

Street Car Orders for Westinghouse.—Contracts for car equipment in one hundred new street cars have been awarded to the Westinghouse Electric & Manufacturing Company by the Brooklyn & Queens Railway Company, of Brooklyn, N. Y. The motors will be of 35 horsepower and duplicate 1340 similar motors sold to the Brooklyn City Railway Company in 1924. The Cleveland Railways Company has placed an order for 100 new city street cars to be built at the Kuhlman plant of the J. G. Brill Company. Each car will be equipped with four Westinghouse 50 horsepower motors.

New Portable Arc Welder by G. E.—A new portable electric arc welding machine announced by the General Electric Company is driven by a 6-cylinder gas engine, and replaces the 4-cylinder engine-driven unit previously included in that company's line. Advantages of the 6-cylinder engine are ease of starting, steadiness of operation and greater capacity. The welding generator is a ball-bearing, self-excited, single-operator machine rated 300 amperes, 1 hour, 50 deg. C. with a current range of 90 to 375 amperes in accordance with N. E. M. A. standards. Included with the set is a current-reducing resistor by means of which welding currents down to 25 amperes may be obtained. The current can be adjusted simply by turning the brush-shifting handle. When operating so that the potential at the generator panel, including reactor drop, is 25 volts, any value of current can be obtained between 25 and 400 amperes.

JOURNAL OF THE A. I. E. E.

DEVOTED TO THE ADVANCEMENT OF THE THEORY AND PRACTISE OF ELECTRICAL ENGINEERING AND THE ALLIED ARTS AND SCIENCES

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Vol. XLVIII NOVEMBER, 1929 Number 11

A Message From the President.

The Centralizing and Coordinating Agencies in the Interrelationships of the Institute

SEVERAL of the more important interrelationships pertaining particularly to the functioning of various internal activities of the Institute have been outlined briefly on these pages in the last three issues of the Journal. With increased growth and scope of the Institute, new external connections requiring coordination likewise have arisen. Therefore, with extension of these contacts, two natural and important influences have been at work. One, due to internal relations, is both centralizing and decentralizing. The other, due to external association, is necessarily centralizing.

With the broader geographical distribution of its membership, a decentralizing influence within the Institute has been recognized, and met, by the establishment of the ten district organizations, each provided with its own executives and committees. Each of these ten district units, and possibly others yet to be established, are charged with the responsibility of furthering the best interests of its particular district through District meetings, prizes, Section and Branch activities, etc. Each one has also the important duty of coordinating its own effort and activity with the centralizing, controlling and coordinating efforts of the Institute's Board of Directors and Headquarters. This obligation whereby each part be cognizant of the whole and the whole cognizant of all its parts has become a most important task. This condition is full of opportunity for both service and experience in the interests of both. Upon mutual effort and ability to meet these problems depends much of the success of both the District and the Institute as a whole.

Upon the Board of Directors, through the executive work of Institute Headquarters, devolves the duty not only of cooperating with and assisting the District organizations but also of centralizing and coordinating the latter's effort to give to the Institute the most efficient organization possible.

Acting for the Board of Directors, the Institute Headquarters, therefore, becomes not only the centralizing, coordinating agent of internal relationships, but also the coordinating unit of the Institute's external activities. As such, it reaches, here and there, for all that is best for the advancement of the theory and application of electrical engineering; the profession of electrical engineering itself, in this and other countries. Thus only can the Institute achieve its purpose. The Board of Directors and National Headquarters with the many ramifications of their work constitute more than the centralizing, coordinating agency of the Institute. As representing the membership of the Institute, they become the centralizing body, in this country, of the entire profession. This position has been won for the Institute through years of earnest devotion to the development of all that pertains to that profession. The recognition of this position carries the added responsibility of cooperation with "the allied arts and sciences" here and abroad.

Harold B. Smith

President

Some Leaders of the A. I. E. E.

P. Junkersfeld, Vice-President of the Stone and Webster Corporation, Associate Member of the Institute 1901, Fellow 1912, and Vice-President 1916-18, was born near Sadorous, Illinois, October 17, 1869. In 1895 he obtained a B. S. degree at University of Illinois, and in 1907, E. E. He has engaged in engineering and construction ever since 1895.

Soon after graduation in 1895, Mr. Junkersfeld entered the employ of the Chicago Edison Company and its successor, with which interests he remained for nearly 24 years. Beginning with two years in power plant operation, he rose in the organization until, in 1899, he became head of the Engineering Department, and in 1909, Assistant Vice-President, supervising the contracting, operating, construction, and electrical departments. He was intimately identified with the Fisk, Quarry, Northwest, and other steam power plants (aggregating over 600,000 kv-a. when he resigned in 1919), and corresponding transmission lines, substations, distributing system and other physical properties; he has also engaged in commercial activities, particularly electric service and power rating and negotiations resulting in supplying power required by all elevated and surface electric railways of Chicago. He served also in the capacity of consultant, and for five years was chairman of a monthly engineering, constructing, and operating conference of various Insull public utilities in several states. In 1916 he became President of the Association of Edison Illuminating Companies. By Josephus Daniels, Secretary of the Navy, he was appointed to the Board of Directors for Industrial Preparedness in Illinois, and was made an Associate Member of the Naval Consulting Board.

He became a member of the Officers' Reserve Corps in February 1917, and on June 7, 1917 began active service in the World War, continuing until March 4, 1919 in the successive ranks of Major, Lieutenant-Colonel and Colonel, engaged in the construction of cantonments, camps, hospitals, port terminals, warehouses, munition plants and other war construction. On July 15th, 1919 Newton D. Baker, Secretary of War, presented him with the Distinguished Service Medal.

In April 1919 he resigned from the Commonwealth Edison Company to become associated with Stone & Webster, Inc., of Boston, as Engineering Manager and executive of the Construction and Engineering Division. During the following three years, this Division constructed about 300,000 kv-a. in 14 steam and four hydroelectric plants and extensions, and about 20,000 boiler horsepower in six industrial and steam heating boiler plants; he also engaged in industrial work including a complete sugar refinery, five rubber works, fabric and hosing works, and other industrial and general construction developments.

In February 1922, he resigned from Stone & Webster, Inc., to become a partner in the firm McClellan & Junkersfeld, Inc., Engineers and Constructors, whose first important work was the design and construction of the Cahokia power plant for the Union Electric Light & Power Co. of Illinois, near East St. Louis, Ill. With extensions and commitments authorized, this plant has a capacity of about 340,000 kw., and a probable ultimate capacity of 450,000 kw. It was the second large public utility electric plant designed to burn exclusively pulverized coal. Engineering service was rendered also for the Cleveland Electric Illuminating Company on its Avon and East 70th Street plants, and engineering and construction service for the new San Francisco steam plant of the Great Western Power Co. in California. In six years, beginning 1922, his firm did engineering, construction, and report work in a total of 21 States and three Provinces of Canada, including about 1,200,000 kv-a. in steam-electric plants, and pulverized coal installations totaling over 110,000 boiler horsepower, exclusive of various industrial installations.

On July 19, 1928 the firm of McClellan & Junkersfeld, Inc., was merged with the Division of Construction and Engineering of Stone & Webster, Inc., to form the Stone & Webster Engineering Corporation, with Mr. Junkersfeld Vice-President.

He has written many technical papers, among them "Multiple *vs.* Independent Operation of Power Plants" (1901); "Periodic Inspection of Steam Turbines" (1907); "Effect of Load Factor on Steam Station Costs" (1921); "Obsolescence as a Factor in Design of Steam Generating Stations" (1923); "General Review of Current Practise in Steam Power Stations" (1924); (The last presented before the First World Power Conference in London jointly by Mr. Junkersfeld and Mr. G. A. Orrok), as well as other articles and discussions before engineering and technical associations and printed in various publications.

He was first President of the Construction Division Association; is a Past-President of Association of Edison Illuminating Companies, and Past Vice-President of Western Society of Engineers. He is also a member of The American Society of Mechanical Engineers; American Society of Civil Engineers; National Electric Light Association; Edison Pioneers; Engineers' Clubs of Chicago and New York; Western Universities Club of New York; the Lawyers' Club; and the Scarsdale Golf Club.

The Year Book of the Czechoslovak Electric Association shows that of a total of 457 electric power stations in that country 311 are owned by power companies and 146 by manufacturers. The power companies generated 719,000,000 kw.-hr. in 1927 with an installed capacity of 396,700 kw. The total energy generated in Czechoslovakia in 1927 amounted to 1,700,000,000 kw.-hr., which gives an average of 125 kw.-hr. annually per capita. This is an increase by 12.5 per cent compared with 1926.

There are 13,000 miles of high-tension transmission lines in Czechoslovakia and the mileage is increasing at the rate of 17.5 per cent a year.

The Theory of Electrical Conductivity

Recent Developments

BY WILLIAM V. HOUSTON*

Non-member

Synopsis.—This paper explains the electrical conductivity of metals in light of recent discoveries regarding the behavior of electrons. It is claimed that these discoveries have made possible a satisfactory theory of conduction. The more important discovery is that of the wave nature of the electrons. The other new discovery is known as Pauli's "exclusion principle" which states that no two electrons in a wire can have exactly the same velocity and direction of motion. In working out the theory, the statistical method of the Fermi distribution function is employed.

The paper shows that the theory satisfactorily explains how there may be emissions of electrons from a hot wire in spite of the fact that very little energy is put into the electrons by raising the temperature, it explains relative resistances of metals and their alloys, the contact potential between metals, the thermoelectric effect, the Peltier effect and the change in resistance due to a magnetic field.

* * * * *

FOR the past 30 or 40 years the attempt has been made in the study of physics to explain all of the properties of matter on the basis of ultimate electrical particles. It has been assumed that a piece of material is made up of a very large number of positively charged particles called protons, and of negatively charged particles called electrons. This assumption is based on the experimental fact that it is possible to separate positive and negative particles from all kinds of matter. The numerical value of the charge on one particle is found to be the same as that on the other. Furthermore, the total numbers of protons and electrons are the same, so that there is no electrical charge on the body; but the mass of a proton is some 1840 times as large as that of an electron, so that the weight of a body is essentially that of the protons. It is found that all of the protons and about half of the electrons are gathered together into small clusters which are the atomic nuclei. These nuclei then have a resultant positive charge, and are surrounded by enough negative electrons to make a neutral atom. The number of positive charges on the nucleus, which is the same as the number of electrons around the nucleus, is equal to the atomic number of the element and determines its position in the periodic system of the elements. This method of interpreting experimental facts has had such tremendous success in so many fields that it seems almost certain that, in its broad outline, it represents correctly the constitution of matter.

With this picture, it is relatively easy to account qualitatively for the electrical conductivity of metals. When the atoms are packed as closely together as they are in a metal, the outer and more loosely attached electrons come under the influence of more than one atom and become free. In other words, they cannot be identified as belonging to one atom or another, and they move about between the atoms with very little restraint. Under these conditions, the application of e. m. f. causes these electrons to filter between the fixed atoms, and so, to constitute a current. On the other hand, an insulator is a substance in which all of the electrons are tightly bound to individual atoms.

This idea was given a quantitative treatment by Drude,[1] Lorentz,[2] and others. They started out by treating the free electrons as though they were alone in the metal and behaved exactly as gas molecules,[3] moving about with energy due to temperature. Thus we come to speak of the group of free electrons as an electron gas. If an e. m. f. is applied to such an electron gas, it starts of course an average motion of all the electrons in one direction. If there were nothing to interfere with the motion, the electrons would move faster and faster, and the current would continue to increase without limit. The limit is set, however, by the presence of the atoms themselves, or more strictly speaking, of the positive ions, which form the crystal lattice. When an electron collides with an ion which is more or less tightly bound to its position in the crystal, the electron loses the extra energy which it has acquired from the field. On this account, its velocity cannot increase indefinitely. Thus the collisions of the electrons with the fixed ions are observed as a resistance, and the resistance is proportional to the number of collisions per second.

It is perhaps desirable to look at the relative magnitudes of some of the quantities involved in this picture. If we make the very reasonable assumption that there is one free electron for every atom, there will be about 6×10^{22} free electrons per cu. cm. When there is no e. m. f. applied, these electrons will be moving with fairly high speeds in all directions, but the average velocity will be zero, so that the electron gas as a whole will not move. This distinction between the velocity of a single electron, and the average velocity of all electrons, which latter is the current, is the same as the distinction between the velocity of the molecules of air and the velocity of the air as a whole. The velocity of the molecules we recognize as heat, while the velocity of the whole we call wind. Now the velocity of a single electron will be of the order of 10^8 cm. per sec., while if

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1. For references see Bibliography.

Presented at the Pacific Coast Convention of the A. I. E. E., Santa Monica, Calif., Sept. 3-6, 1929. Printed complete herein.

the average velocity of the whole is as great as only one cm. per sec. there will be the tremendous current of about 8000 amperes per sq. cm. or about 50,000 amperes per sq. in. This shows that the applied e. m. f. produces only a *very minute* change in the velocities of the electrons.

All this, of course, has nothing to do with the propagation of the e. m. f. along the wire. That is governed by Maxwell's equations and can be explained as a result of the mutual repulsions of the electrons. This mutual repulsion can be neglected except, perhaps, in the finer details of the theory of conductivity.

Qualitatively, this picture is very satisfactory; but there are very serious difficulties with the quantitative treatment. In the first place, if there is at least one free electron for each atom in the metal, the electron gas should have a specific heat about half as large as that due to the vibration of the ions which make up the crystal. But the observed specific heat is merely that of the ions themselves. This constitutes a very serious objection to the classical theory, since it indicates that not enough energy is put into the metal when the temperature is raised to account for the assumed increased energy of the electrons. In the second place, the number of free electrons which must be assumed to explain the different electrical properties of a metal varies between such wide limits that the theory, is evidently inconsistent. Another difficulty is that when the resistance is calculated by means of this theory it is found to be proportional to the square root of the temperature, which is not at all in accord with the observed facts.

On account of these difficulties, many attempts have been made to give other pictures of the behavior of the electrons in a metal. Some of these have been based on the idea that the electrons do not become free from the atoms, but remain attached and under the influence of an applied e. m. f. occasionally pass from one atom to the next. In this case, of course, the electrons need have no specific heat, since they do not move independently of the atom. But it is just this lack of an independent motion which makes it difficult to explain the emission of electrons from hot wires which we use in thermionic vacuum tubes. It is usually thought that this is due to the fact that certain electrons acquire a very high velocity and so are able to pass through the retaining wall of potential which bounds the metal. If there is no motion due to temperature energy, this could not be the case.

Thus, until recently, the theory of the electrical properties of metals contained a number of conflicting hypotheses, and it seemed impossible to form a consistent theory with a few simple assumptions. Within the last few years, two important discoveries have changed the whole aspect of the situation. Perhaps the more important of these discoveries has been the discovery of *the wave nature of the electrons.*

For several centuries there have been two rival explanations of the phenomena of light,—the wave theory and the corpuscular theory. During the nineteenth century, the weight of evidence became almost overwhelmingly in favor of the wave theory, but with the discovery of the photoelectric effect in 1888, it became necessary to use the corpuscular theory, (which has been called the quantum theory), to explain the phenomena of the interaction of light with matter. But although there have been two theories of light, there has been only one theory of the nature of electrons. Since the very early experiments on cathode rays, there has been practically no doubt as to the nature of electrons. They seemed in every way to satisfy the requirements of corpuscles of electricity. No one ever thought of investigating the wave properties of electrons until it was accidently discovered in 1927 that a stream of electrons produces a diffraction pattern in the same way as a beam of X-rays.[3] Many theoretical considerations had been pointing toward the necessity of treating electrons as waves under some circumstances. Through this experimental confirmation of the theory, *we have now just as good evidence for saying that a stream of electrons is a train of waves as we have for saying the same thing about a beam of light.* The quantum theory, which was so called because it seemed to require that light should be propagated in corpuscles or quanta, has now come to include the requirement that electrons should have the properties of waves. This duality of nature, of both light and electrons, is now a firmly fixed experimental fact. It is one of the discoveries which has made possible a satisfactory theory of electrical conduction.

The other essentially new feature in the present theory is known as Pauli's exclusion principle. Applied to the problem in hand, this states that no two electrons in a wire can be in the same quantum state, *i. e.,* they cannot have exactly the same velocity and direction of motion. At first this seems an outrageous restriction, and yet there is a great deal of experimental evidence in favor of it. It is the basis of the theory of the periodic system of the chemical elements, as well as the very extensive and satisfactory theory of spectra. This principle, combined with the fact of the wave nature of the electrons, makes it necessary to revise the statistics with which we treat the electron gas in a metal.

On account of the large number of electrons with which we have to deal, it is necessary to use the methods of statistical mechanics. There are several different varieties of statistics, each one adapted to dealing with a certain kind of object. It is perhaps easiest to characterize the different types of statistics by giving their distribution functions. These functions give the number of electrons which may be expected to have velocities in a given range.

The classical statistics were developed largely by Maxwell and Boltzmann, and are adapted to the treat-

ment of material particles. The distribution function for these is

$$dn = A\, e^{-mv^2/2kT} \quad d\,\xi\, d\,\eta\, d\,\zeta \qquad (1)$$

This means that dn is the number of electrons, on the average, whose velocity components in the x, y, and z directions lie between ξ and $\xi + d\,\xi$, η and $\eta + d\,\eta$, ζ and $\zeta + d\,\zeta$. v is the total velocity, k is the molecular gas constant, m the mass of the electron, and T is the absolute temperature. The curve of this function for two different temperatures is shown in Fig. 1. It is evident from Equation (1), as well as from

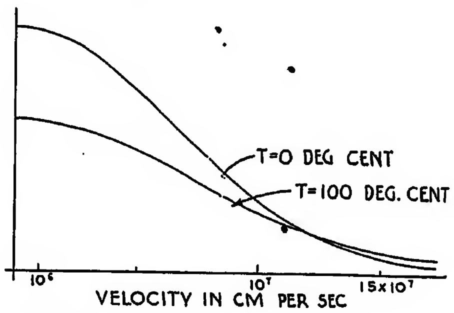

FIG. 1—THE MAXWELL OR CLASSICAL DISTRIBUTION PLOTTED AS A FUNCTION OF VELOCITY

Fig. 1 that as the temperature increases, the curve becomes more and more spread out, so that more electrons are found with high velocities.

The theory of quantum statistics with which we are concerned was developed by the Italian Fermi,[4] and independently by the Englishman Dirac. It is based on assumptions which make it applicable to wave motions when the Pauli exclusion principle applies. Thus, according to our latest knowledge concerning the nature of electrons, it should apply to electrons. The distribution function in this case is

$$dn = \frac{2\,m^3}{h^3}\;\frac{1}{\dfrac{1}{A}\,e^{\,mv^2/2kT} + 1}\; d\,\xi\, d\,\eta\, d\,\zeta \qquad (2)$$

where the letters have the same significance as in Equation (1); h is known as Planck's constant of action and characterizes all equations in the quantum theory. The constant A in both functions is determined so that the integral of dn over all possible values of v gives the total number of electrons present. In the Maxwell distribution function in Equation (1), A is merely a constant by which the exponential function is multiplied, but in the Fermi distribution, the size of A determines the nature of the function. If A is very much smaller than 1, the first term in the denominator is so large that the other may be neglected. The function then becomes the same as the Maxwell function. But in the opposite case, the functions are entirely different. The value of A, when A is large, can be determined from the equation

$$\log A = (h^2/2\,m\,k\,T)\,(3\,n/8\,\pi)^{2/3} \qquad (3)$$

where n is the number of electrons per cu. cm. Because of the very large number of free electrons when it is assumed that there is one per atom, A for ordinary metals is about 10^{90}. Thus, only the case where A is very large need be considered. Fig. 2 shows the curve of the Fermi distribution function for two different temperatures when A is given this value. A gas for which the constant A is greater than unity is called degenerate, and the size of A is a measure of the degeneracy.

It is evident from the curve and from Equation (2) that in the case of the highly degenerate electron gas, the temperature has only a very slight effect on the velocities of most of the electrons. Only the relatively few which have the higher velocities are affected at all. Since the temperature has very little effect upon the motion of the electrons, it follows that the specific heat of the electron gas is very small; in fact it is given by

$$C_v = (\pi^2\, m\, k/h^2)\,(8\,\pi/3\,n)^{2/3}\, R\, T \qquad (4)$$

where R is the gas constant for one gram molecular weight. For room temperature, C_v is less than 1 per cent of the value to be expected with the Maxwell distribution. This is one of the important successes of the present electron theory of metals and was pointed out by Sommerfeld[5] who developed the statistical

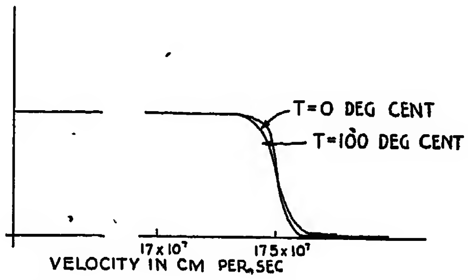

FIG. 2—THE FERMI DISTRIBUTION FUNCTION PLOTTED AS A FUNCTION OF VELOCITY

The scale of this figure is not at all comparable with that of Fig. 1.

phase of the theory. *Now it can be understood why the electron gas makes practically no contribution to the specific heat of the metal.*

But although the free electrons have a very low specific heat, they do not have a low energy of agitation. It is merely that this energy is not given up when the metal is cooled, but is retained and exists at the absolute zero of temperature. The average velocity of a free electron in a metal is of the order of 10^8 cm. per sec. This high velocity and the accompanying energy produces a pressure on the surface of the metal which amounts to something like 2×10^5 atmospheres. Even with this pressure, however, the majority of the electrons are unable to escape from the metal because of the strong electric field which exists at the surface. But there will always be a few with extra large velocities, which can penetrate this surface layer and escape

from the metal, and the number of these increases with the temperature.

In Fig. 3, the Fermi distribution function for the degenerate electron gas is plotted with the energy instead of the velocity, for the horizontal axis. W_i represents the energy at which the function has dropped to ½, while W_a represents the energy which an electron must have to escape from the metal. The electrons which escape are those represented by the part of the curve to the right of W_a. By calculating the number of electrons represented by this part of the curve, and taking account of the various directions in which they are traveling, Sommerfeld has shown that the current per sq. cm. coming from a hot wire is given by

$$I = (4\pi e m/h^3)\, k^2 T^2 e^{-(W_a - W_i)/kT} \tag{5}$$

The equation derived by Dushman and others is:

$$I = B T^2 e^{-b/T} \tag{6}$$

In Equation (5) $(W_a - W_i)/k$ takes the place of b in Equation (6). This shows that the b which is usually measured and called the work function, is not really the energy necessary for an electron to have in order to escape from the metal, but is the difference between

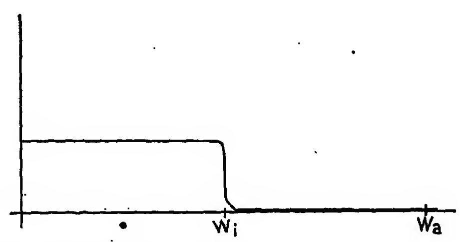

Fig. 3—The Fermi Distribution Function Plotted as a Function of Energy

this energy and an energy which represents the pressure of the electrons inside the metal. In this way, the theory explains completely why we can get emission of electrons from hot wires in spite of the fact that very little energy is put into the electrons by raising the temperature.

The outstanding electrical property of a metal is that of conductivity. It was mentioned above that a current is a relatively slow drift of all the electrons under the influence of an applied e. m. f. This drift would become faster and faster if it were not for the fact that the electrons collide with the metal atoms and so lose the acceleration they have gained from the field. Thus, the average gain in speed and the current is proportional to the time for which an electron can travel without a collision. The average distance which the electron can travel without making a collision is called the mean free path, and this quantity is generally used for calculation instead of the mean time between collisions. Sommerfeld has shown that when the Fermi statistics is used to describe the velocity distribution of the electrons, the specific conductivity in electrostatic units is given by

$$\gamma = (8\pi e^2/3h)\,(3n/8\pi)^{2/3}\, l \tag{7}$$

In this equation e is the charge on one electron, h is Planck's constant of action, n is the number of free electrons per cu. cm., and l is the mean free path for those electrons whose energy is equal to the W_i of Equation (6); l is of the order of 5×10^{-6} cm. The mean free path is, of course, a function of the velocity, but only the length of the mean free path at this particular velocity is essential in the conductivity.

In Equation (7) all of the quantities except l are independent of the temperature, and so we must explain the fact that resistance increases with temperature by the fact that l decreases with temperature. It is here that the wave nature of the electron becomes directly apparent. The wavelength of an electron wave is determined by the velocity of the electron through the relation

$$\lambda = h/m v \tag{8}$$

This shows that the faster electrons have the shorter waves. From the Fermi statistics, it can be shown that the free electrons in a metal have such velocities that practically all of the wavelengths are greater than about 5 A or 5×10^{-8} cm. They are longer than most X-rays. This fact is of importance when we study the effect of a crystal upon these waves.[6] The behavior of an electron in a crystal can be considered from two points of view which correspond to the two natures of the electron. From the corpuscular point of view, the electron makes collisions with the atoms in the crystal and so is deflected from its path. From the wave point of view, the electron wave is diffracted by the crystal in the same way that a light wave is diffracted from an optical grating. In the case of electrons in a metal, the wave point of view is the correct one to use. Hence, the problem of determining the resistance of a metal is the same as the problem of determining the scattering of the electron waves by the atoms which form the lattice of the metallic crystal.

It is possible to calculate this scattering effect by the methods used for calculating the diffraction of X-rays by a crystal, when proper allowance is made for the difference in wavelength. The electron waves are longer than the distances between the atoms of most crystals, so that if the atoms were really stationary and regularly arranged, there would be no scattering at all, and hence, no resistance whatever. This is not the explanation, however, of the phenomenon of superconductivity, nor of the fact that the resistance becomes zero when the absolute temperature becomes zero, for there is very good evidence that the atoms in a crystal are not stationary, even at the absolute zero of temperature. There are still other ways in which the resistance may become zero, although if there were no motion of the atoms in the lattice, it would certainly be zero.

The thing that produces the diffraction of the electron waves and consequently the resistance is an irregularity in the arrangement of the metallic atoms. This ir-

regularity may come about either through the presence of impurities which distort the arrangement of the atoms, or through the motion due to the temperature energy. This latter effect produces the resistance in pure metals, while the first effect explains why the resistance of an alloy is always greater than the resistance of at least one of its constituents. It is easy to understand from this the reason for Matthiessen's rule which states that a small amount of impurity causes a small added resistance which is independent of temperature. This is explained by the fact that the irregularity in the crystal due to the impurity is essentially independent of temperature.

It is possible to calculate the resistance due to the heat motion of the metal atoms. This kind of calculation shows that the resistance, in its dependence on temperature, may be closely approximated by

$$R \text{ is proportional to } 1/x_0 \int_0^{x_0} \frac{x^4\, dx}{(e^x - 1)\,(x^2 + a\, x_0^2)^2} \quad (9)$$

$x_0 = \theta/T$, where θ is a function of the elastic constants of the metal and T is the absolute temperature; a is a measure of the scattering power of a single atom and so is characteristic of the metal. Equation (9) shows that for ordinary temperatures, the resistance is proportional to the absolute temperature, while for lower temperatures, it falls off more rapidly than would be indicated by the simple proportionality with temperature.

The agreement of Equation (9) with the observations shows that the knowledge of the wave nature of the electron has made it possible *for the first time to give a satisfactory explanation of the way in which the resistance depends on the temperature.*

In addition to the phenomena already mentioned, there are several others which are explained in a satisfactory manner by the present theory. The sudden increase of resistance, which always appears when a pure metal is melted, is due to the destruction of the regularity of the crystal by the metal. The atoms in the solid have a regular arrangement, to a certain extent, while the atoms in the liquid are moving about at random. This loss of regularity causes a large increase in the scattering of the electron waves and a correspondingly large increase of resistance.

The fact that the resistance of a non-cubical metallic crystal is different in different directions can be attributed to the fact that the atoms in the non-cubical crystals can vibrate more easily in one direction than in the others. This causes the diffraction of the electron waves to vary with the direction. The corresponding difference in resistance, calculated on this basis, agrees very well with the observed differences.

A number of other effects, such as the contact potential between different metals, the thermoelectric effect, the Peltier effect, and the change in resistance due to a magnetic field, receive a consistent and satisfactory explanation on the basis of the Fermi statistics and the wave nature of the electron.

The study of atomic structure, which has engaged the attention of physicists for the past 30 years, has now come to the stage where it is possible to treat not only single atoms, but molecules and those very large molecules which we know as solid bodies.

The first extensive application to solids has been the electron theory of metal which has been developed by Sommerfeld, Houston, Frenkel, Nordheim and Bloch.[7] This brief outline has sought to indicate the degree of success with which the modern theory of the electron has provided a unified treatment of this baffling physical problem.

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MOTION PICTURE CAMERA IN ELECTRICAL TESTING

The following brief résumé of an article describing the use of a motion picture camera in making certain electrical tests is given through the courtesy of Mr. Frank E. Fisher, of Chicago.

There appears in the February, 1929 issue of *The Transactions* of the South African Institute of Electrical Engineers an interesting article describing the use of a moving picture camera in connection with certain tests where meters of the oscillograph or recording variety are not applicable.

The general method is to mount the meters, which vary with the type of test to be run, on a panel and then take moving pictures of the instruments. Thus, the data taken by an ampere-hour meter, voltmeter, wattmeter, frequency-meter, speed indicator, etc., are accurately recorded on the film and can be studied at leisure. This method obviates the use of a man to read each instrument, thus avoiding the inaccuracy of the human element.

The readings may be taken on 16 mm. or 35 mm. standard film and many of the cameras on the market which have a fairly wide range, can be used. A spring-operated camera has been tried with good results.

The author of the article, who is also the originator of the method of test, suggests various uses for the scheme and illustrates the set-up which was used in studying the operation of the skip in a metal mine. In this case eleven instruments were mounted. The scheme was originated by Mr. L. B. Woodworth of the Central Mining and Investment Corporation of South Africa, and the experiments were conducted at the No. 14 Shaft of Crown Mine, and were eminently successful. The method is also being experimented with by the Victoria Falls Power Company.

Abridgment of

Dial Telephone System

Serving Small Communities of Southern California

BY F. O. WHEELOCK[1]

Member, A. I. E. E.

Synopsis.—This paper briefly reviews the history of the step-by-step dial telephone system in small communities of metropolitan areas, and notes some of the reasons for its recent, rapidly growing use in small towns and communities apart from metropolitan areas. The wider appreciation of improved service by the public in the last three years is noted, and requirements of the service now being rendered are discussed. The equipment is described, and the methods of operation and maintenance are given. The affect on outside plant, building design, and other incidentals is discussed, as are also the results obtained in the use of this telephone system.

Introduction

In rendering telephone service, two systems are in general use; the manual system and the dial system. As the names imply, the fundamental difference between these two systems is that in the manual system, the principal central office operations for completing telephone calls are made by hand, and in the dial system they are made by machine. Today, dial telephone systems are in use in a great many places, chiefly in exchanges of considerable size with equipment arranged as a single unit having a capacity of ten thousand terminals or multiples thereof. The idea of providing telephone service for the smaller community by means of dial system equipment housed in small buildings and normally unattended is by no means new but its use in this manner has been limited for reasons explained later on.

It is the purpose of this paper to describe the small step-by-step dial telephone system. First, a brief history of its development is given, followed by a discussion of some of the considerations which led to its rather wide use in Southern California. Then a description is given of the equipment employed and its operation and maintenance. The exchanges specifically referred to are located in the area shown in Fig. 1.

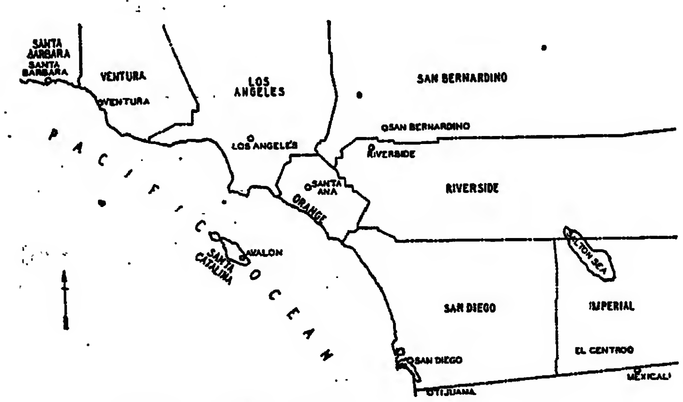

Fig. 1—Map of Southern California

Reasons for Adopting Present System

More than 15 years ago, there were several small dial offices of the step-by-step type serving portions of the Los Angeles and San Diego exchanges. Then these were known as "branch offices" and "automatic sub-offices." Each was in fact a part or an extension of the large dial office to which it was directly connected. Fig. 2

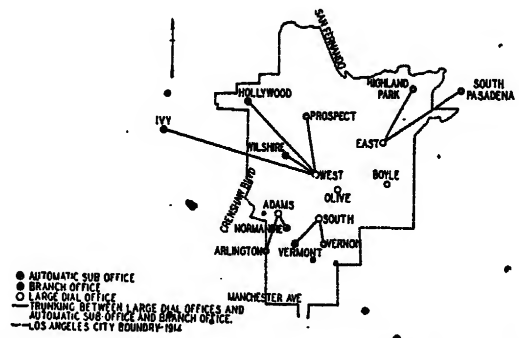

Fig. 2—Map of Los Angeles, Showing Small Dial Offices in 1914

shows the location of these offices in the Los Angeles exchange at that time. The branch office was fully attended, and while the sub-office was smaller and more of a complete unit in itself, it also required rather constant attendance.

The recent growing demand for full 24-hour service in progressive communities, and an effort to secure greater economy and efficiency in giving better service, were probably the motivating forces exerted in promoting in 1926 the idea of using dial equipment for serving the small community with equipment operating independent of the larger or nearby exchange except for trunking and for trouble alarm signals.

A study was made in the latter part of 1926, and plans were formulated for installing a modern small dial telephone system in the rapidly growing new town of San Clemente, California. Other installations have since been completed so that at the close of 1929, fourteen towns are similarly equipped. These are shown in Fig. 3 and include the following exchanges:

1. Southern California Telephone Co., Los Angeles, Calif.

Presented at the Pacific Coast Convention of the A. I. E. E., Santa Monica, Calif., September 3-6, 1929. Complete copies upon request.

Arcadia, Buena Park, Dana Point, Fontana, Imperial, La Mesa, Ojai, Pacific Beach, Piru, Rancho Santa Fe, Reseda, San Clemente, San Ysidro, Vista.

In addition, the following other small communities in the same area are now served by step-by-step dial telephone systems, each including some of the features described herein:

Artesia, Barstow, Beaumont, Bellflower, Downey, Hynes, Indio, La Habra, Lynwood, Mar Vista, Norwalk, Palm Springs, Rivera, Victorville.

Service Requirements

A fundamental requirement in rendering universal telephone service is to have an operator readily available to the user in case assistance is necessary in completing a connection. This precludes the use of a telephone system that is mechanically operated in its entirety. In the small dial telephone system, this feature is taken care of by operators located at a center serving usually more than one exchange.

To insure satisfactory operation when called upon by the subscriber while dialing a number, the equipment requires routine supervision of its operation at various periods. It also requires attention to predetermine defects, potential and actual, that may cause trouble. Therefore, from the standpoint of maintenance, also, it is not entirely unattended.

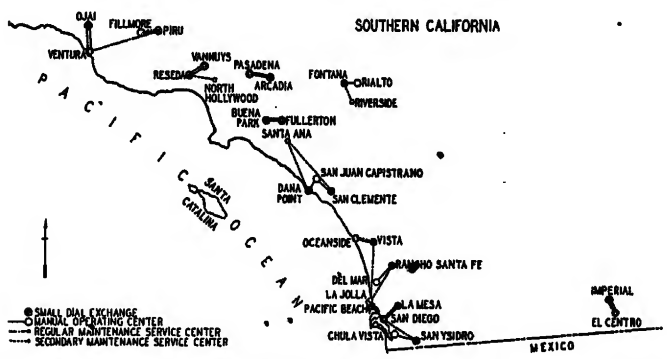

Fig. 3—Small Dial Offices, Manual Operating Centers, and Maintenance Service Centers

In addition, successful operation of a dial telephone system depends upon a third human factor,—the subscriber. The equipment may be designed, installed, and maintained properly with an operator readily available, but its operation will not be a success unless the subscriber uses his telephone properly.

Description of the Equipment

The outstanding items of improved central office equipment used are line finders rather than line switches; self-protecting apparatus which permits of omitting heat coils in the battery supply leads; reverting call selectors; 10-party code ringing connectors; choice of postpayment dial or postpayment manual coin box equipment; trouble alarm signals extending to the center from which the dial office is supervised; power plants with start and stop of charging current automatically controlled; and ringing machines automatically controlled by selectors for the smaller exexchange and continuously running for the larger exchange.

The regular subscribers' line equipment consists principally of line and cut-off relays. Dial coin box subscribers' line equipment consists of similar relays and associated equipment to furnish the necessary tone to indicate to the subscriber when to deposit a coin. Manual coin box subscribers' line equipment consists of a concentrating switch of the rotary type to connect the line to a trunk leading directly to the manually-operated center, and relays similar to those in the regular subscribers line.

In appearance, the line finder is similar to an ordinary selector, but in addition, it has a commutator and associated wiper for level hunting; it is a part of the call originating equipment and is used to connect the line of a calling subscriber to a first selector.

Local selectors are of the usual two-wire type universally used for local or incoming service. Toll selectors also are of the type used in the larger dial office. They are equipped with contacts that close with the vertical operation of the switch to operate a relay for controlling the start of the ringing machine in the offices where continuously run ringing machines are not employed.

Connectors are of the type used for the various classes of service, including one-bell, two-bell, rotary hunting, 10-party code ringing and toll.

Where transmission is satisfactory over the local train, toll selectors and toll connectors are not provided.

Repeaters are of the usual type.

Long line equipment consists of the usual relay, resistance, repeating coil, and condenser equipment to increase the normal impulsing and signaling range of the subscribers line.

The arrangement of the trouble alarm equipment includes visual and audible alarms which are extended to the adjacent manual operating center.

Ample testing equipment, for all central office equipment and for subscribers' line and station equipment, is furnished.

Distributing frames are of the floor or wall type, the protector usually terminating the outside cable.

The relay rack is of the usual channel iron type, and on it are mounted the long line, alarm, and other miscellaneous relay equipment.

The power plant includes storage batteries of either the portable or stationary type, and arrangements for facilitating maintenance, such as automatic voltage regulators, Tungar rectifiers, ampere-hour meters for the automatic starting and stopping of the charging current, and ringing machines, either continuously running or those controlled by selectors.

When the present movement toward the wider use of dial equipment for the small community was started, it was with a thought that by omitting operators rest

rooms, facilities for preparing lunches, etc., the central office quarters could be provided at much less expense than for manual equipment.

So far, use has been made of the standard 11-ft. 6-in. frames and racks, as in the large dial exchanges. Frames of heights 9 ft. 1¼ in. and 8 ft. 5¾ in. also have been used in some offices. These have required rooms with a fairly good ceiling height. As previously mentioned, however, it is expected that within a short time there will be available an equipment using

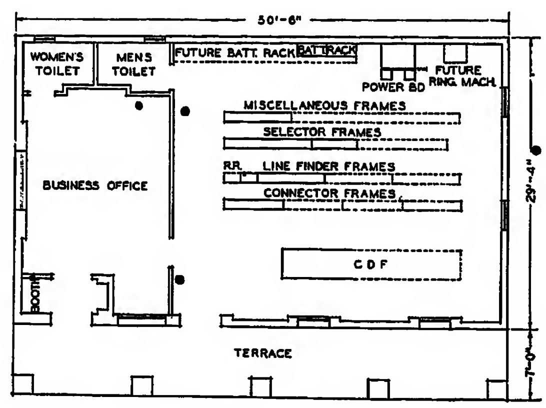

Fig. 6—Floor Plan, Ojai

frames and racks limited to 7 ft., together with self-contained units for the mounting of line finders, selectors, and connectors which will permit of installing equipment in rooms 9 ft. in height.

The arrangement and floor space occupied by the equipment for one of the exchanges is shown in Fig. 6.

Some of the earlier offices were not provided with heating apparatus. It has been found necessary, how-

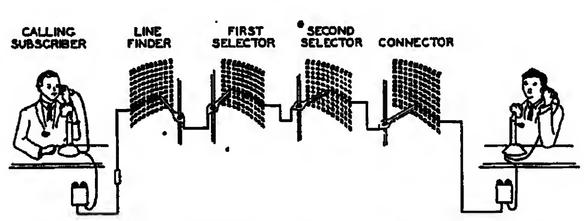

Fig. 7—Path of Local Call—Small Dial Office

ever, to place either gas or electric heaters in the majority of the small dial offices. When in use, these are regulated by thermostatic control and during cold or damp weather are operated continuously.

Method of Operation

On an ordinary call, when a dial system subscriber removes his receiver, the line finder automatically connects the line to an idle first selector. The subscriber hears the dial tone, which indicates that he is connected to a first selector and that he may dial the number. The first digit of the desired number is dialed. The selector responding to the dial impulse is raised to the desired level, and, finding an idle trunk, cuts the line through to the connector. In offices where the total terminals exceed 1000, a second selector is inserted in the circuit between the first selector and the connector. With the dialing of the last two digits, the connector steps up vertically and around horizontally until the dialed number is reached, at which time, if the line is not busy, the ringing starts. The ringing tone is heard by the calling party until the called party answers. If the line called tests busy, a busy signal is heard by the calling party. Fig. 7 shows the path of the call for a completed connection. If the called number is on a 10-party line, an additional digit is assigned. When this final digit is dialed, a minor switch, which is part of the connector, operates in a rotating motion and upon completion of the dialing, completes a circuit to relay equipment which sends out the required number of rings on the tip or ring side of the called line. The above method of operation is nearly identical with the method of operation in use in large exchanges where the line finder step-by-step type of equipment is employed.

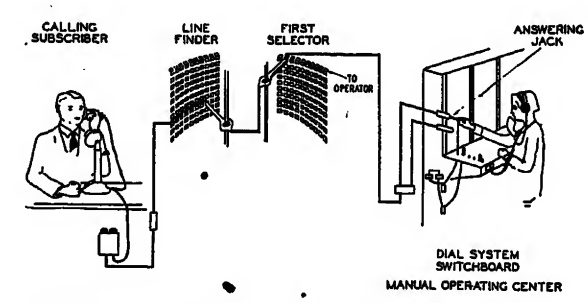

Fig. 8—Path of Call from Small Dial Office to Manual Operating Center

Numbering plans consisting of three and four digits are used in smaller exchanges, and those of four and five digits are used in the larger exchanges. As previously stated, where code ringing is used, the last digit indicates the code ring.

On out of town calls and assistance calls the subscriber dials "0" to connect with the operator at the manual center, as shown in Fig. 8, and the operator completes the call to the distant toll point. In handling assistance calls from the small dial exchange, the operator may dial the desired number over the regular paths to test for "busy" or "don't answer". Fig. 9 shows the path of an incoming call through the manually operated center to a dial system subscriber.

Where rotary hunting connectors are not provided, private branch exchange service is given by listing all the trunk numbers in the directory. In most small dial exchanges, no intercepting service is given for changed numbers, disconnected numbers, and vacant terminals; failure to hear the audible ringing signal is an indication to the subscriber that he has selected a vacant level or terminal.

Reverting calls,—*i. e.*, calls to other stations on the same line,—are obtained by calling a three-digit number, first dialing nine, then the last digit of the calling sub-

scriber's number, followed by the last digit of the called subscriber's number.

No special provision is made for absorbing false preliminary impulses other than that level No. 1 of first selectors is not ordinarily assigned, but is used initially as a vacant level.

Coin box stations are of the multi-slot postpayment type. Local numbers are dialed from dial coin box stations in the same manner as from any other dial station. When the called party removes his receiver from the hook, a distinctive tone is heard by both parties, which is an indication to the calling party to deposit a coin. When the coin is deposited, the tone is removed, clearing the circuit and connecting it through for the conversation.

Maintenance

In the operation of any telephone plant, some maintenance effort is necessary to keep the equipment in good workable condition. The proper amount to give a good balance between maintenance effort and the quality of service rendered is desirable. In the larger central offices this is accomplished through systematic methods

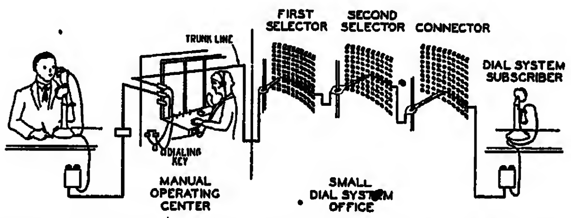

Fig. 9—Path of Incoming Call through Manual Operating Center to Small Dial Office

whereby the equipment is made to function on test on a somewhat more stringent margin than would normally be met with under the worst operating condition. Tests are made through the medium of test circuits designed to simulate the various conditions under which the apparatus is designed to function.

While the equipment specified for small dial offices is practically the same as that used in large dial offices and requires the same treatment, the amount of maintenance effort necessary to keep the apparatus functioning, due principally to the low calling rate, is considerably less than that required for the large office. The routine methods employed in a great many instances are identical, but include some special tests for apparatus peculiar to this type of equipment.

These routine tests are made at intervals in proportion to the importance of the apparatus.

In addition to routine testing, the trouble signals and alarms facilitate maintenance of the equipment. The alarm signals are made common and are routed over trunks or individual circuits to the operating center to inform the operator of trouble during periods when no one is present at the dial office.

For the purpose of making routine operation and observation of the equipment, visits to the small dial office by the maintenance men were first scheduled weekly. Later it was found possible to extend the frequency without causing service reaction, so that the minimum period between visits is two weeks. For the Reseda Exchange, the equipment routines require the attention of a central office repairman for about five hours every two weeks. Considering the amount of equipment involved, the number of cases of trouble recorded as a result of routine tests has been negligible.

Outstanding in conditions noted is the adaptability of the central office and outside repairmen, who have been trained and have had their experience principally in the manual system, to handle quickly the equipment of the step-by-step dial system.

Results Obtained

Some of the results obtained that have caused additional study and action, as well as those that are favorable, are recorded in the following matter.

Outside Plant. Some trouble has been experienced from low insulation on open-wire trunk circuits which are in operation between San Clemente and San Juan Capistrano, a distance of approximately 7½ mi. This trouble occurs only in dry climates where there is considerable dust accumulation and where rains are not sufficiently frequent to keep the insulators washed clean. Salt spray on the insulators from the ocean which is nearby also aggravates the situation. This condition has been under careful observation and has been cared for tentatively by scrubbing the insulators with brushes and water at intervals. While final conclusions have not yet been reached as to the most practical way to permanently care for this condition, it is thought that the installation of cable for a portion or the entire distance may be warranted.

At Fontana, one of the small communities first provided with dial equipment, rather serious service conditions existed during the first few months of operation due to various outside plant conditions. Winds of great velocity are frequent and several of the open-wire leads pass through trees. These lines, swinging together, operated line finders nearly continuously, causing unnecessary wear and at times tying up the available paths for traffic in the office to an unsatisfactory degree. This condition was met by rather extensive rebuilding of outside plant and the service has been improved to a grade comparable to that of large dial offices. In general the small dial system does not require any better grade of outside plant than the manual system.

Buildings. The introduction of the small dial office has involved the construction of many new buildings for the small exchange, thus offering an opportunity to improve their appearance. Considerable thought has been given to beautifying the outside as well as the inside of the structure. These small dial exchange buildings are scattered over a wide area and all conditions of topography and climate are met.

Simplicity of Equipment. The avoidance of a multiplication of refinements in service and in ways of performing one and the same service are essentials to be kept in mind and closely controlled in the continued success of the small dial system. An open-minded public and company, both ready to waive the nonessentials for the essentials, have made it possible to omit, in most cases, features such as intercepting service on unconnected terminals, to permit of simplification of the plant.

The small dial system must give satisfactory service at low cost and a careful course must be pursued to keep down the investment to permit of operating economically.

Psychological Aspect. Visitors to these small offices, who know of the quality of the service in these exchanges, have been impressed with the fact that notwithstanding the doors being locked; yet as they enter, they view in fitting surroundings a clean nearly perfect machine which is functioning continuously with very little human aid to give this service.

Today, the maintenance man is sure in his own mind of what the equipment does and will do in the future; he therefore goes about his work expecting the proper performance of the system and it functions accordingly. Before experience was gained by actual use, it was the natural thing for all to be looking for causes that would prevent proper operation. Now, however, skepticism is a thing of the past, the system has proved satisfactory and its permanent use is assured. Pessimism has changed to constructive suggestion which can only result in improvement.

Abridgment of

Transmission and Distribution

ANNUAL REPORT OF COMMITTEE ON TRANSMISSION AND DISTRIBUTION*

To the Board of Directors:

The work of the Committee on Power Transmission and Distribution covers a wide field and may logically be divided into the following classifications:

- Lightning and surge problems on overhead lines
- Insulator design for overhead lines
- Design of towers and poles for overhead systems
- Cable development for underground systems
- System connections and stability factors
- Standardization activity
- Research activity.

The work carried on this year has been confined to the lightning and insulator problems handled by a subcommittee under the leadership of Mr. Sporn, cable development handled by a subcommittee under the direction of Mr. Peterson, and system connections and stability factors handled by a subcommittee under the direction of Mr. Evans, with Mr. Farmer coordinating the standardization activities and the research work carried on under the direction of a joint research committee working under the auspices of the N. E. L. A. Underground Systems Committee, Association of Edison Illuminating Companies' Committee on High Tension Cable, and the Power Transmission and Distribution Committee of the A. I. E. E.

The problems arising under the above activities are so closely related with similar problems handled by other committees of the Institute and other organizations that considerable attention has been given to coordinating this work so as to eliminate unnecessary duplication and at the same time insure the proper handling of all subjects. In light of this condition, your committee has not initiated any work on inductive coordination and any consideration of the interference aspect of such subjects is being tied in with the work of the Joint General Committee and the activity of the work on stability factors and interconnection has been referred to the Committee on Coordination of Institute Activities for assistance in subdividing this work between the various committees.

A summary of the developments and problems arising during the year is covered in the following reports from the subcommittees:

SUBCOMMITTEE ON LIGHTNING AND INSULATORS

PHILIP SPORN, CHAIRMAN

General Aspects of the Lightning Problem

Lightning disturbances on electric circuits have always been a problem; the importance of these disturbances becomes greater with the increase of interconnecting high-voltage lines transmitting large blocks of power, which now form the backbone of interconnec-

*COMMITTEE ON POWER TRANSMISSION AND DISTRIBUTION:
H. R. Woodrow, Chairman,

R. E. Argersinger,	E. W. Dillard,	E. R. Northmore,
Geo. M. Armbrust,	R. E. Doherty,	L. L. Perry,
R. W. Atkinson,	L. L. Elden,	T. F. Peterson,
E. T. J. Brandon,	R. D. Evans,	D. W. Roper,
V. Bush,	F. M. Farmer,	A. E. Silver,
P. H. Chase,	Harland C. Forbes,	L. G. Smith,
C. V. Christie,	C. L. Fortescue,	H. C. Sutton,
D. D. Clarke,	K. A. Hawley,	Percy H. Thomas,
W. H. Cole,	V. L. Hollister,	Philip Torchio,
R. N. Conwell,	J. P. Jollyman,	Theodore Varney,
M. T. Crawford,	A. H. Kehoe,	H. L. Wallau,
W. A. Del Mar,	A. H. Lawton,	H. S. Warren,
Herbert H. Dewey,	W. E. Mitchell,	R. J. C. Wood.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

tion and in many cases, the basis of economic generation. The transmission line therefore becomes a vital link in the electric circuit, and lightning, by its adverse effect on its operation, its worst enemy. The demand for more reliable line operation, from a lightning standpoint, has started investigation and research, beginning with isolated field investigations with crude and limited instruments, next laboratory research with the lightning generator, and then to field investigation with the klydonograph and surge recorder; and finally, to the cathode ray oscillograph in both the laboratory and field.

Both the laboratory and field have contributed to the solution of the lightning problem. The laboratory by offering complete and easy control of the lightning wave has, of course, rendered investigations far more simple than field research.

Theory, too, has contributed its part in studying the mechanism of cloud formation and lightning discharges, the breakdown of the discharge path, the influence of ground wires, the characteristics of the electrostatic field, the effect of traveling waves on electric circuits, and the shape and effect of different shapes of traveling waves on the insulation strength of the line and the connected apparatus. A noteworthy contribution to the study by the field is the record of lightning disturbances and trouble on lines as encountered in actual service, together with complete storm data where available.

Finally, an extension of the development has been made in combining the laboratory and field in the form of artificially created lightning imposed on actual transmission lines. Certain problems that prove difficult of solution, such as wave propagation, can best be handled that way.

With this background, it is clear that the solution of the lightning problem has received progression acceleration the past few years, and a large amount of lightning data has been secured and many of the results published in the technical press. Even with considerable theoretical analysis and the laboratory and field data available, the lightning problem is not solved. Some phases of lightning are only partly known, others are in dispute, and some are definitely not known.

Committee Program Planned

An attempt will be made to coordinate a program of determining more definitely what is known about lightning as affecting electric circuits. A careful correlation of lightning data and theories which may appear to be conflicting should bring forth information that is needed in the solution of many of our problems.

The lightning problem of electric circuits is primarily an insulating problem and consequently requires not only a study of voltage stresses but the installation characteristics necessary to withstand these stresses or at least localize the trouble to the least damaging point.

Lightning Progress During 1928

A large amount of data has been provided to indicate the magnitude of lightning voltages and attenuation of this voltage and characteristics of traveling waves as result of the three cathode ray oscillographs and the numerous klydonographs and surge recorders which have been connected to the systems during the past year. Artificial lightning surges have been placed on transmission lines, making it possible to observe with a cathode ray oscillograph the behavior of the lines under various conditions which have considerably accelerated the establishment of data of this character.

Extension in the use of ground wires and the use of grading shields on insulator strings has been made during the past year, and the practise of reducing the line insulation for a mile or so out from the substation to protect station equipment has been extended.

Research Work in Progress

Surge investigation installations are in progress on transmission lines of a number of operating companies. Some ten or twelve cathode ray oscillographs are planned to be in operation on actual lines during the coming summer. Two or more additional installations to record the performance of artificial lightning are also planned for this summer. It is expected that this extensive program will be very effective in obtaining greater amount of information on lightning and surge characteristics.

SUBCOMMITTEE ON CABLE DEVELOPMENT

T. F. PETERSON, CHAIRMAN

General Statement

The portion of last year's Power Transmission and Distribution Committee Report dealing with cable developments included descriptions of what might be considered remarkable advances and great strides in the transmission art. Of these, the design, installation, and operation of 132-kv. oil-filled cable were most notable. This year, nothing so sensational is to be noted. Practically all development and improvement seem to have been characterized by a tendency toward review and analysis of existing practises, stabilization, and reduction of known methods and principles to economic and practical feasibility. These have apparently constituted the bases for such crucial investigations of paper insulated cable of the so-called solid type, sheath corrosion, sheath current mitigation, temperatures of conduits, etc., as have been reported in the technical press throughout the year. The fine cooperation and coordination of results evidenced by various organizations, utilities, and manufacturers engaged in the improvement of cable bids fair toward hastening the day of our profound understanding of cable and its operation.

Research

The annual report of the Impregnated Paper Insulated Cable Research Subcommittee gives a compre-

hensive picture of the extent of the research activities which have been greatly expanded during the last few years and indicates the spirit of cooperation which is now displayed in the industry.

At Massachusetts Institute of Technology, an extensive investigation of the rate of deterioration of wood-pulp paper for cable insulation when subjective to heat alone has been concluded. It appears from this investigation that impregnated wood pulp paper will withstand temperatures at least as high as manila paper and that the permissible operating temperatures of high-tension cable could be considerably increased above the present prescribed values.

At Johns Hopkins University the investigation of the effects of residual air and moisture in the insulation indicates that the difficulties with commercial cables are due largely to extended areas of entrapped air and gases resulting from imperfect impregnation, distortion in handling, or expansion of the lead sheath rather than the lack of extremely low pressure of impregnation.

The study of the laws governing ionization characteristics of cable insulation has progressed at Harvard University to the point where simple empirical equations have been established for the experimental curves.

The accelerated life tests on cable carried on by the Brooklyn Edison Company and the test of insulation of the solid type carried on by the Detroit Edison Company are adding valuable data to this problem. The Commonwealth Edison Company is conducting an elaborate theoretical study of the fundamental nature of insulation under the auspices of Utilities Research Commission.

Developments in Practise

The 132-kv. lines installed last year in Chicago and New York have continued to operate without electrical failures, and an additional circuit is being installed this year in New York. This year's development shows important advancement in the method of installation in that it is possible to install the cable filled with oil, thereby eliminating the field impregnation required on the first development.

The several installations of 45-kv. and 66-kv. single-conductor cable of the solid insulation type have continued to give satisfactory service, and during the past year, a pioneer installation of three-conductor oil-filled cable for 33-kv. operation has been made in Chicago. The satisfactory operation of the oil-filled cable indicates that similar construction can be used for higher voltages up to at least 66-kv. The improved regulation of the three-conductor cables and the elimination of sheath losses, together with the other features of superiority, make this type of construction appear attractive as compared with three single-conductor cables.

The shielded or Hochstadter type of construction continues to find favor for three-conductor cables in the 22- to 33-kv. class. The use of oil reservoirs on the joints has proved very beneficial and thus far the possible trouble which some engineers feared from the expansion of cable sheath has not been manifested. For the lower voltages of 11-kv. to 15-kv., three-conductor cables and single-conductor cables installed three per duct have been used more or less indiscriminately with advantages being claimed for both.

It has long been felt that our present method of rating cables, based on temperature limit of insulation, was, to say the least, unsound. The lack of a suitable alternative has accounted for the retention of the present method, but with the coordinated investigations now in hand, it may be expected that data will be available before long to set up a rational method of rating cables.

During the past year, considerable interest has been exhibited in sheath corrosion, and several companies have observed the formation on lead sheath of various red, orange, and white compounds. Inasmuch as these, especially the red lead oxide, made their appearance on cable installed in monolithic concrete duct, which is coming into very general use, they gave rise to considerable alarm among those operating and extending such systems. Almost coincidentally, there was reported considerable corrosion of lead sheath in creosoted wood ducts.

Through the concerted investigation of the Utility companies and the Portland Cement Association it was found that the presence of calcium hydroxide from the concrete, water and a-c. electrolysis conspired to produce the oxide. The elimination of the water or electrolysis will prevent the formation, or if the concrete is allowed to stand for approximately twenty-eight days, thereby allowing the calcium hydroxide to change to calcium carbonate, the cables should be relatively free from corrosion of this type.

The corrosion in wood ducts was found to be due to acetic acid evolved from the Douglas fir used for the conduit and the remedial measure applied in this case was the introduction of ammonia gas into the duct, thus neutralizing the acid.

Specifications, Testing, and Operation of Cable

There has been no important change in cable inspection and testing practise during the year. Specifications remain practically unchanged except for an increase in test voltages for single-conductor and shielded type multiple conductor cables, as well as a decrease in the allowable ionization factor in high-voltage cables. As in previous years, a survey of the test results obtained shows a general trend in the direction of improvement. This is indicated by the percentage of deficiencies and the uniformity of insulation resistance, power factor, and ionization factor. This consistent trend toward improvement is now being reflected in decidedly better operation of cable as revealed in annual reports of operation which have been compiled. Analytical studies of the mass of data that is collected annually in connection with acceptance inspection and testing

of cable and of failures of cable which occur in service, have been carried on for several years. The value of these studies as an aid in improving cable having been demonstrated, more effective means of carrying them on has been developed under the cooperative auspices of the National Electric Light Association and the Association of Edison Illuminating Companies. This development is another indication of the cooperation which exists in the industry and which cannot help but be a great aid to progress.

STANDARDIZATION ACTIVITY

F. M. FARMER, CHAIRMAN

The following is a brief summary of standardization activities which have been consummated during the year.

1. Section No. 30 of the Standards of the A. I. E. E. dealing with wires and cables has been submitted to the American Standards Association for ratification as an American Standard (minus certain items which are now under discussion).

2. Specifications for annealed copper wire, both bare and tinned, were approved as American Standard by the American Standards Association June 12, 1928.

3. Specifications for 30 per cent rubber insulation for wire and cable for general purposes were approved by the American Standards Association as tentative American Standard April 2, 1928.

4. Specifications for magnet wire were approved by the American Standards Association as tentative American Standard April 2, 1928.

A number of matters dealing with wires and cables is in the course of development to the standardization stage. Specifications for impregnated paper insulation, specifications for varnished cloth insulation, and specifications for weatherproof heat resisting and other coverings are being developed by the Sectional Committee on Wires and Cables of the American Standards Association. Similarly, progress is being made with the development of a standard stranding table for stranded conductors by the same committee.

Informal arrangements have been made between the appropriate committees of the National Electric Light Association and the Association of Edison Illuminating Companies for the coordinated collection and study of cable failures on a standardized basis.

SUBCOMMITTEE ON INTERCONNECTION AND STABILITY FACTORS

R. D. EVANS, CHAIRMAN

Interconnection of power systems has been brought about as a natural result of consolidation under a common management or as a measure to reduce investment or operating expense of systems under separate managements. The general advantages, such as those arising from load diversity, generating reserve, and utilization of stream flow plants, have been recognized for some time. The problems at hand have to do with the determination of the economy of a particular undertaking and the selection of the best method of carrying out the interconnection.

One of the most important aspects is the reliability of the power supply obtained from the interconnection. Reliability depends to a large extent on the vulnerability and stability of the system, *i. e.*, its capacity to maintain the machines in synchronism at times of system disturbances. These problems are very prominent in the field of power transmission, as the means of interconnection consist of transmission lines or ties with the associated transformers and switching equipment, and as the location, number, and character of these ties largely determine the serviceability of the interconnection.

The study of system connections is a development whose importance has recently become generally recognized. While it is true that different power system connections have developed in different parts of the country, these differences could largely be explained because of the difference in the local situation as to the transmission distance, the density, and the distribution of the load. Increase in the extent of systems and of interconnection has made it necessary to give consideration to what are commonly called "system problems," of which stability may be cited as an example. Stability was first carefully analyzed in connection with long-distance power transmission. More recently, these principles are being applied in the study of the closely-connected systems.

The plan of operation of interconnected systems may be premised on either the maintenance of synchronism at times of system disturbances or upon the separation of the systems. In the latter case, the system may be split at fixed points or at variable points to coordinate connected load and generating capacity. At the present time it is not possible to draw any general conclusions as to the proper field of application of these different methods of operation.

In the design of systems to maintain stability, several distinct methods are recognizable. Synchronism may be maintained (1) by measures which increase the synchronizing power which may be transferred between the machines, as by the use of low reactance tie lines or the application of quick response excitation; (2) by measures which limit the severity of the shocks to the system occasioned by faults, as may be affected by the use of individual lines of high reactance or by quicker fault isolation; or (3) by a system layout which causes the shock to be distributed to the various machines in such a way as to accelerate or decelerate them as a unit.

In order to improve stability, special attention is being given to the characteristics of apparatus to be used on extensive systems and interconnections. From the standpoint of stability, governors should operate quickly and should possess anti-hunting features tending to reduce oscillations after disturbances. Governor operation in direct response to fault indications may prove advantageous. Field test to indicate perform-

ance of governors under transient conditions would be very desirable.

In generators, high short-circuit ratio and low transient reactance are of benefit in improving the power limits. The use of the proper kind of excitation system extends the power limit under both steady state and transient conditions and may largely overcome the disadvantages of low short-circuit ratio. Low transient reactance will improve the stability conditions at times of system fault. In general, a study should be made to determine in each case the proper value of machine transient reactance which depends upon line and transformer as well as generator costs.

Consideration is being given to the use of damper windings in waterwheel generators. Damper windings tend to improve stability by virtue of their damping action and to decrease stability because of the increase in fault current due to the reduction in negative phase sequence reactance of the generator. Investigations have indicated that in certain cases, damper windings may be advantageous provided they are of the proper characteristics.

Excitation systems capable of quick response are effective in improving stability under steady state and particularly under transient conditions. In special cases the use of synchronous condensers, wholly or principally as an aid to stability, will be found desirable. The stabilizing effect of such condensers will be increased by the application of suitable quick response excitation systems.

During the past year, active field tests and investigations have been made regarding quick response excitation systems, increased insulation of lines, the speedy disconnection of a defective circuit from the system and the introduction of ground resistor or reactance (Peterson coil).

The extension of systems and interconnections have introduced operating problems important from the standpoint of stability. The greater complication of systems has temporarily required the human element to a greater extent which is being offset by the further development of automatic features such as control of frequency, voltage, and switching.

The theoretical investigation of stability has proceeded to a point where fundamental operating data are urgently needed. Information as to the operation of systems has been obtained in the past principally from indicating and graphic instruments which have been provided for the convenience of the operators. During the past few years a number of instruments with speed-up devices has been used, but the general results have not been entirely satisfactory because of the delay in starting the device and the inaccuracies in the measuring elements. Recently these objections have been reduced by the use of an oscillographic type of instrument, and the tendency is to use such devices where transient records of disturbances are desired. The importance of records of this nature is becoming more apparent in reconstructing the nature and extent of system disturbances, particularly where considerable power is being transmitted over some distance. With such data available, it will be possible to place the design requirements upon a sounder basis; for example, it should be possible to determine whether the basis for maintaining stability should be predicted upon a single fault to ground as is commonly done at present, or upon the less frequent double fault to ground. Such data will also make it possible in many cases to estimate from oscillation with existing loads, the probable system disturbance with future loads.

General Conclusion

The expansion of the interconnection of systems has brought numerous problems to the engineer for solution and it is to be noted in the foregoing subcommittee reports and the several papers presented before the Institute that fundamentally different ideas of system developments have been brought out to meet the ever increasing demand for higher continuity of service and greater flexibility of supplying relatively large blocks of load from a network system. Your committee expects rapid strides to be made within the next few years in handling distribution problems and predicts radical departures from old methods and practises.

CHAIN DRIVES FOR FACTORIES

Chain drives have been developed during the present generation into a practicable means for transmitting power in industry. They have established themselves as a most satisfactory and trouble-free way of transmitting power from an electric motor to a line shaft or directly to a machine tool. The positive nature of the drive prevents loss from belt slippage, and such loss is loss of production, not merely loss of power, writes A. C. Woodbury, in the October issue of the *S. A. E. Journal*, an official publication of the Society of Automotive Engineers.

A silent chain drive that is intelligently selected for the job and installed in good alignment will operate for years with no attention other than lubrication, periodic inspection and possibly two or three adjustments of center distance.

The silent chain drive has been found to fill a great need in power transmission, because it furnishes a positive drive that is much more compact than a belt drive and much more flexible than a gear drive, according to the author. The compactness makes it available in individual drives from motors to machine tools with little or no additional floor space required for the motor. Motors can often be mounted directly on the tool, to make a self-contained unit that can be moved about and placed as required for convenience in manufacturing; without reference to anything like a line shaft.

Abridgment of

Parallel Operation of Transformers Whose Ratios of Transformation are Unequal

BY MABEL MACFERRAN*

Associate, A. I. E. E.

Synopsis.—An equation is developed for use in meeting emergency conditions which necessitate the paralleling of transformer banks whose impedances expressed in percentage are not equal. This equation makes it possible to calculate what change should be made in the ratio of transformation of the bank with the lower percentage impedance in order to prevent its being overloaded when the total load approaches the combined capacity of the two banks. It is pointed out that such an expedient is a makeshift justifiable only when maintenance of service is the paramount consideration and efficiency is for the time being of secondary importance. When conditions arise which do justify such a temporary arrangement, the method developed in the present paper affords a simple yet accurate means of solving the problem.

* * * * *

INTRODUCTION

EMERGENCIES sometimes arise in which it becomes desirable to operate in parallel transformer banks whose characteristics are not ideally suited to such a procedure. It is well known that unless the impedances of the two banks, expressed in percentage form, are approximately equal, one bank will assume too much load in proportion to its rating; the other too little. The question then arises whether it is possible so to change the ratio of transformation of one bank that under the most severe load conditions which are to be imposed on the combination, neither bank will be overloaded.

The purpose of the present paper is to derive an equation whereby the change in ratio necessary to accomplish the desired result may be calculated. Such an equation is very much needed, as the only method which, to the writer's knowledge, is now extant for attacking the problem is based on the regulation curves of the two banks and involved errors which make it, in many cases, somewhat inaccurate.

It should be clearly understood that the expedient of changing the ratio of transformation of one bank relative to that of the other is not being advocated as a permanent measure, as it results in marked inefficiency of operation. It is justifiable only as a temporary step to be adopted under emergency conditions which require a certain peak load to be carried, no matter what the cost in efficiency at lighter loads.

FUNDAMENTAL EQUATIONS FOR PARALLEL OPERATION

Since the principles governing the parallel operation of two three-phase banks are exactly the same as those governing the parallel operation of two transformers in a single-phase circuit, the discussion will be based on the simple case of two single-phase transformers in parallel.

It will be assumed throughout the discussion that the load is connected to the low-tension side of the paralleled transformers.

The fundamental considerations, which control the behavior of two transformers operating in parallel are very simple. They are:

1. The voltage impressed on the high-tension winding of one transformer is equal to, and in phase with, that impressed on the high-tension winding of the other transformer.
2. The voltage appearing at the low-tension terminals of one transformer is equal to, and in phase with, that appearing at the low-tension terminals of the other transformer.

From the first consideration it follows that the low-tension open-circuit voltages of the two transformers are in phase with each other.* The reason is that neglecting the very small phase displacement caused by the exciting current, the low-tension open-circuit

FIG. 1—TRANSFORMERS OF UNLIKE RATIO IN PARALLEL OPEN-CIRCUIT CONDITION

voltage of each transformer is in phase with the voltage impressed on its high-tension winding. The two low-tension open-circuit voltages are not equal in magnitude, however, unless the ratios of transformation are equal in the two transformers. The vector diagram for open-circuit conditions is shown in Fig. 1. In this diagram, $\bar{E}_1$ represents the low-tension open-circuit voltage of Transformer 1, and $\bar{E}_2$, that of Transformer 2.

When a load is applied to the low-tension side of the paralleled transformers, the impedance drop in each transformer must be of such magnitude and direction that the second consideration is satisfied, as shown in Fig. 2.

In expressing these relations mathematically, the following symbols will be used:

$\bar{E}_1$ = low-tension open-circuit voltage of Transformer 1
$\bar{E}_2$ = low-tension open-circuit voltage of Transformer 2

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Presented at the Pacific Coast Convention of the A. I. E. E., Santa Monica, Calif., Sept. 3-6, 1929. Complete copies upon request.

*"Parallel Operation of Transformers," Waldo V. Lyon, *Elec. World*, Vol. 63, No. 6, February 7, 1914, p. 315 ff.

$\overline{V}_1$ = low-tension terminal voltage of Transformer 1
$\overline{V}_2$ = low-tension terminal voltage of Transformer 2
$\overline{I}_1$ = current in low-tension winding of Transformer 1
$\overline{I}_2$ = current in low-tension winding of Transformer 2
$\overline{I}_L$ = current flowing to the load
θ_L = angle between load current and voltage impressed on the load
ϕ = angle between voltage impressed on high-tension side of the transformers and voltage appearing at low-tension terminals
D = arithmetical difference between $\bar{E}_1$ and $\bar{E}_2$
Z_1 = equivalent ohmic impedance of transformer 1, referred to low-tension side
Z_2 = equivalent ohmic impedance of transformer 2, referred to low-tension side.

From Fig. 2, the following equations may be written:

$$\overline{V}_1 = \bar{E}_1 - \overline{I}_1 Z_1 \tag{1}$$

$$\overline{V}_2 = \bar{E}_2 - \overline{I}_2 Z_2 \tag{2}$$

$$\overline{V}_1 = \overline{V}_2 \tag{3}$$

The simultaneous solution of these equations gives:

$$\bar{E}_1 - \bar{E}_2 = \overline{I}_1 Z_1 - \overline{I}_2 Z_2 \tag{4}$$

Since $\bar{E}_1$ and $\bar{E}_2$ are in phase with each other, if

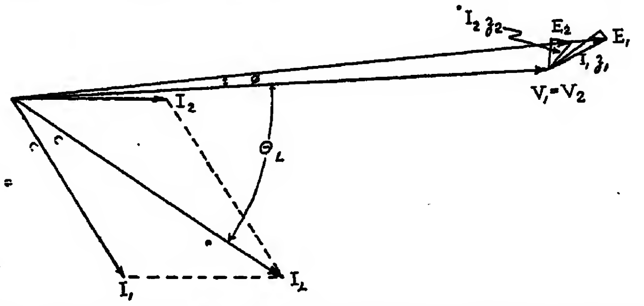

FIG. 2—TRANSFORMERS OF UNLIKE RATIO IN PARALLEL LOAD CONDITION

$\overline{V}_1 = \overline{V}_2$ be selected as the reference axis, we may write:

$$\bar{E}_1 - \bar{E}_2 = D\underline{/\phi} \tag{5}$$

Equation (4) may then be written as follows:

$$\overline{I}_1 Z_1 - \overline{I}_2 Z_2 = D\underline{/\phi} \tag{4a}$$

It is also necessarily true that:

$$\overline{I}_1 + \overline{I}_2 = \overline{I}_L \tag{6}$$

Equations (4a) and (6), if solved simultaneously, give the following result:

$$\overline{I}_1 = \frac{\overline{I}_L Z_2 + D\underline{/\phi}}{Z_1 + Z_2} \tag{7}$$

$$\overline{I}_2 = \overline{I}_L - \overline{I}_1 \tag{8}$$

It should be noted that the use of the specific vector $D\underline{/\phi}$ in place of the general vector expression $(\bar{E}_1 - \bar{E}_2)$ ties Equations (7) and (8) definitely to $\overline{V}_1 = \overline{V}_2$ as a reference axis.

Equations (7) and (8) make it possible, given the difference existing between the ratios of transformation of the two transformers, to calculate the division of current for any specified total load. It must be borne in mind that *the solution will be correct for only the one load*, and that the currents will shift in relative magnitude and in relative phase position as the magnitude and power factor of the load are changed.

It will be seen at once that there is one difficulty in the way of obtaining a direct solution for Equation (7). This difficulty is that since the phase position of $\overline{V}_1 = \overline{V}_2$ depends upon the magnitude and phase position of $\overline{I}_1$ and $\overline{I}_2$, the value of ϕ is not known until $\overline{I}_1$ and $\overline{I}_2$ are known. Fortunately, this difficulty is of little practical importance, since the angle ϕ is usually so small that it may be set equal to zero with only a slight resulting error in the solution. If it is desired to carry the calculation to greater accuracy, the method of successive approximations may readily be applied; that is, ϕ may first be set equal to zero, the solution made, and the position of $\overline{V}_1 = \overline{V}_2$ calculated. Then, with the value of ϕ obtained from this calculation, a new solution of Equation (7) may be made.

The impedances substituted in Equations (7) and (8) should be in the form of complex quantities, having both resistance and reactance components. The values used should be those applying to the taps on which the transformers are operating. This requirement will be found to offer something of a stumbling-block in practise, as the data ordinarily available give information only on the full-winding impedance values. It is beyond the scope of the present paper to discuss ways of estimating the tap values of impedance other than to point out that as the transformer is placed on lower and lower taps, the impedance values referred to the winding on which the taps are situated generally decrease quite slowly, whereas the impedance values referred to the other winding *increase* rather rapidly. The exact mode of variation depends on the type of core, type of winding, and location of the taps. There is urgent need of published data on this subject. Such data being at present lacking, the engineer confronted with a problem in parallel operation must either rely upon estimates based on his own experimental tests, or neglect the variation of impedance with taps altogether. If only an approximate solution is required, the latter course may be adopted.

If the problem at hand involves three-phase transformer banks, the application of Equations (7) and (8) is permissible, providing the ordinary rules for working with one phase of a three-phase circuit are followed. In Appendix A will be found a more detailed discussion of this subject, with especial reference to the case in which one bank is delta-Y and the other, Y-delta.

RATIO CHANGE TO GIVE A DESIRED CURRENT DIVISION

It is now easily possible to derive an equation which will give D in terms of the anticipated load current and the desired division of current between the transformers. It is only necessary to specify that

$$\overline{I}_2 = \bar{A}\,\overline{I}_1 \tag{9}$$

In this relation, $\bar{A}$ is a vector quantity. Its magni-

tude will ordinarily be taken such as to make the ratio of the currents the same as the ratio of the transformer ratings. *Preferably* its angle would be zero, placing $\bar{I}_1$ and $\bar{I}_2$ in phase with each other; but it will be shown that it is not possible to specify *both* the magnitudes and the angle of $\bar{A}$.

By substituting condition (9) in Equation (8), there is obtained the relation

$$\bar{I}_1 = \frac{\bar{I}_L}{\bar{A} + 1}$$

Substituting this in turn in Equation (7), there results:

$$D/\underline{\phi} = \frac{\bar{I}_L (Z_1 - \bar{A} Z_2)}{\bar{A} + 1} \qquad (10)$$

Since D is by definition a pure arithmetical quantity, it is necessary that the expression on the right of Equation (10) come out as some quantity at an angle ϕ. In general, for a specified magnitude of $\bar{A}$, there is only one angle of $\bar{A}$ that will result in a vectorially correct solution to Equation (10). This means that it is possible to dictate the proportion between the currents $\bar{I}_1$ and $\bar{I}_2$, but it is not possible simultaneously to dictate the angle that shall exist between them.

The correct angle for the vector $\bar{A}$ must be found by trial and error. It is usually sufficiently accurate to assume ϕ approximately equal to zero. Then, having selected the desired magnitude for $\bar{A}$, it is necessary to try different angles for $\bar{A}$ until one is found which makes the right-hand side of Equation (10) come out to some quantity at an angle within two or three degrees of zero. D is then equal to this quantity. If greater accuracy is desired, the method of successive approximations may be applied to fix the value of ϕ more closely. However, in practical work, it is not necessary to make an extremely accurate solution for D, because the anticipated load conditions are usually somewhat vague; and furthermore, there is seldom a tap available to conform exactly to the calculated value of D.

If D comes out positive, the open-circuit voltage of the transformer which was assigned, the designation "2" is the one to be lowered, since Equation (7) from which Equation (10) is derived is based on the assumption that $\bar{E}_1$ is greater than $\bar{E}_2$. If D comes out negative, then the open-circuit voltage of Transformer 2 is to be raised above that of Transformer 1. In starting a solution, it is a good plan to assign the designation "2" to the transformer with the lower percentage impedance, because this will be the one whose open-circuit voltage will have to be lowered in order to prevent its taking too much load. Thus the inconvenience of working with a negative D will be avoided.

If the angle which it is necessary to assign to $\bar{A}$ in order to obtain a solution for D is of the order of 90 deg. or more, it is probable that the solution will be of little practical value, since even though the currents divide in proportion to the ratings, each will have to be so large (in order that their vector sum may equal $\bar{I}_L$ despite the large angle between them) that the transformers will in all likelihood be overloaded.

If it seems impossible to find an angle for $\bar{A}$ that works out satisfactorily, some other magnitudes for $\bar{A}$ will have to be tried. Of course there is no use trying magnitudes which differ markedly from the ratio of the ratings unless there is a very wide leeway between the load to be carried and the sum of the ratings of the transformers.

A minor difficulty presents itself in assigning the correct values to Z_1 and Z_2. Their values will depend on what taps are employed on the transformers, and these in turn will depend on the value of D. Here, if desired, the method of successive approximations may be applied. First solve for D, using the full-winding values of Z_1 and Z_2. Then, if to obtain the required D it is necessary to place one or both transformers on taps, estimate the values of Z_1 and Z_2 on these taps and solve again for D. Repeat if necessary until little change occurs in D on the successive solutions. For practical work it is probable that the first value of D will be quite accurate enough, especially since the actual taps available may be such as to make it impossible to use the exact value of D obtained from the solution.

The reasonable procedure in attacking a practical problem is to make a solution for D, using the full-winding impedance values and assuming $\phi = 0$. Ascertain what taps come nearest to giving the required difference in ratio. Then assume the transformers placed on these taps and check the current division by Equations (7) and (8), using the values of Z_1 and Z_2 appropriate to the taps employed, and still assuming $\phi = 0$. Finally, when $\bar{I}_1$ and $\bar{I}_2$ have been found, check the value of ϕ by graphic construction or calculation, and if it differs from zero by more than two or three degrees, make a new solution based on this corrected value of ϕ.

In most practical cases, the magnitude and power factor of the load are a little hard to predict. The best procedure is to select a value of D to fit the most severe load conditions which are anticipated. Then in order to be sure that there is no possibility of overload occurring on one of the transformers, check the current division not only for this but for several other possible values of load and power factor.

If D is selected to give the best possible current division conditions when the total load is of a magnitude approaching the combined capacities of the transformers, it will be found that as the load decreases the current vectors tend to swing further and further apart, until at no-load they are 180 deg. apart and constitute a pure circulating current. On account of this increasing predominance of the circulating component at light loads, it is usually advisable to take the smaller transformer out of service when the total load drops to a value within the capacity rating of the larger transformer.

Conclusions

Equations have been derived which, for a specified

total load at a specified power factor, determine the division of current between transformer banks which differ not only in impedance but also in ratio of transformation.

A formula has been developed for use in meeting emergency conditions which necessitate the paralleling of transformer banks whose impedances expressed in percentage form are not equal. This formula makes it possible to calculate what change, if any, can be made in the ratio of transformation of the bank with the lower percentage impedance in order to prevent its being overloaded when the total load approaches the combined capacity of the two banks.

It has been shown that when the ratio of transformation of one bank is changed in order to produce approximately correct load division under peak conditions, very inefficient operation results when the load drops below the peak value. Therefore, the expedient of ratio change is justifiable only when maintenance of service is the paramount consideration and efficiency is, for the time being, of secondary importance.

When emergency conditions arise which do justify a change of ratio, the method developed in the present paper affords a simple and yet accurate means of solving the problem.

Appendix A

Application of Equations to Three-Phase Transformer Banks

If the banks which are to be operated in parallel are both Y-connected on the low-tension side, Equations (7), (8) and (10) may be applied by using the low-tension line-to-neutral voltage and the impedance of one transformer in each bank. The currents to be used are the line currents flowing in the low-tension side of each bank and in the load.

If the banks are both delta-connected on the low-tension side, the equations may be applied by using the low-tension line-to-line voltage and the impedance of one transformer in each bank. In this case, the currents to be used are the low-tension line currents divided by the square root of three.

If one bank is Y-connected on the low-tension side and the other delta, the simplest procedure is to convert the delta connection into a fictitious Y connection which will have the same percentage impedance as the actual delta-connected bank. In order to derive an expression for the ohmic impedance of each transformer in the fictitious bank, it will be convenient to adopt the following symbols.

$\bar{V}_a$ = Rated voltage across low-tension side of each transformer in actual bank

$\bar{V}_f$ = Rated voltage across low-tension side of each transformer in fictitious bank

$\bar{I}_a$ = Rated current in low-tension winding of each transformer in actual bank

$\bar{I}_f$ = Rated current in low-tension winding of each transformer in fictitious bank

Z_a = Equivalent ohmic impedance of each transformer in actual bank (referred to low-tension side)

Z_f = Equivalent ohmic impedance of each transformer in fictitious bank (referred to low-tension side)

Since the actual bank is delta on the low-tension side, while the fictitious bank is Y, it follows that:

$$\bar{V}_f = \frac{\bar{V}_a}{\sqrt{3}}$$

$$\bar{I}_f = \sqrt{3} \times \bar{I}_a$$

$$Z_a = \frac{\text{Rated voltage} \times \text{per cent impedance}}{\text{Rated current} \times 100}$$

$$= \frac{\bar{V}_a}{\bar{I}_a} \times \frac{\text{Per cent impedance}}{100}$$

$$Z_f = \frac{\bar{V}_f}{\bar{I}_f} \times \frac{\text{Per cent impedance}}{100}$$

$$= \frac{\bar{V}_a}{\sqrt{3} \times \sqrt{3} \times \bar{I}_a} \times \frac{\text{Per cent impedance}}{100} = \frac{Z_a}{3}$$

That is, if the equivalent ohmic impedance (referred to the low-tension side) of each transformer in the fictitious bank is taken equal to one-third that of each transformer in the actual bank for which it substituted, the per cent impedance of the fictitious bank will be the same as that of the actual bank. The same reasoning applies of course to the resistance and reactance components of the impedance.

When the calculation of equivalent ohmic impedance referred to the low-tension side is based directly upon data giving the per cent impedance of the transformer, the ratio of transformation does not enter the problem, and so it makes no difference whether the high-tension winding of the fictitious bank is Y or delta. However, the ratio of transformation does enter the calculation when it is desired to ascertain the taps to give a specified value of D. Here it is necessary to remember the rules as to what types of three-phase connection can and cannot be paralleled, in fixing the ratio of transformation of the fictitious bank. For example, if one bank is Y-Y and the other delta-delta, the fictitious bank which replaces the delta-delta bank must be Y-Y, *not* delta-Y. Or, if one bank is delta-Y and the other Y-delta, the fictitious bank which replaces the Y-delta bank must be delta-Y, *not* Y-Y. The ratio of transformation of the fictitious bank should be fixed accordingly.

In Appendix B of the complete paper an example is worked out which illustrates the method of forming a fictitious delta-Y bank to replace an actual Y-delta bank.

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2. "The Parallel Operation of Transformers," J. Murray Weed, *Elec. Wld.*, Vol. 52, No. 21, November 21, 1908, p. 1117 ff.

Abridgment of

Impulse Insulation Characteristics of Wood-Pole Lines

BY H. L. MELVIN*

Member, A. I. E. E.

Synopsis.—This paper gives the results of a rather comprehensive series of tests on the impulse insulation characteristics of wood, combinations of insulators and wood as used in wood-pole transmission line construction and methods of protecting wood from damage; also a brief discussion on applications of the data.

* * * * *

I. INTRODUCTION

THE tests, results of which are covered by this paper, were made for the purpose of obtaining some fundamental data on the impulse insulation characteristics of wood as used in the construction of transmission lines. Quantitative values were desired, even though they might be only relative, on the insulation strength of poles, crossarms, combinations of insulators and wood, variations between different species of wood, influence of moisture and contamination, and methods of protecting wood from damage due to lightning flash-over. These data should make it possible to use wood in a more intelligent manner in design and also supplement the lightning research investigations.

II. TEST IMPULSE WAVE

Impulse voltages ranging from 400 kv. to 3000 kv. were employed. The voltage wave used for all tests can be described as one reaching its crest in approximately one-fourth of a microsecond and then decreasing to one-half of its maximum value in approximately 20 microseconds.

While the sparkover voltage values would vary with the type of impulse wave used, and this wave may not necessarily be representative of actual lightning, the results obtained should be comparative, and indicative of performance under lightning conditions.

The test points were, of course, rather erratic but sufficiently consistent to plot the average curves shown by the figures. The dashed portions are interpolations and extensions.

III. IMPULSE SPARKOVER VOLTAGES

General. Sparkover voltage tests were made on cedar, chestnut, and treated pine poles; fir and treated pine crossarms; treated hardwood and pine sticks; combinations of insulators and crossarms; insulators and poles; insulators, crossarms and poles; air-gaps; and insulators alone. The combinations corresponded to those which might be used for 66-kv. to 132-kv. construction.

Samples of each of the varieties of poles, crossarms, and sticks were tested dry, surface wet, tap water soaked for about two weeks and salt water soaked (about one-fourth as salty as sea water) for two weeks. Wet cement was also applied to samples to simulate contamination.

Poles, Crossarms, and Sticks. In testing the poles, crossarm, sand sticks it was learned that the variety of wood, treatment, moisture content, contamination or salt water soaking had little influence on the sparkover voltage values. The results are shown by Figs. 3 and 4. The poles and crossarms were taken from service or stock and the sticks were five to ten square inches in cross-section, of selected quality, considered suitable for use as long wood guy insulators.

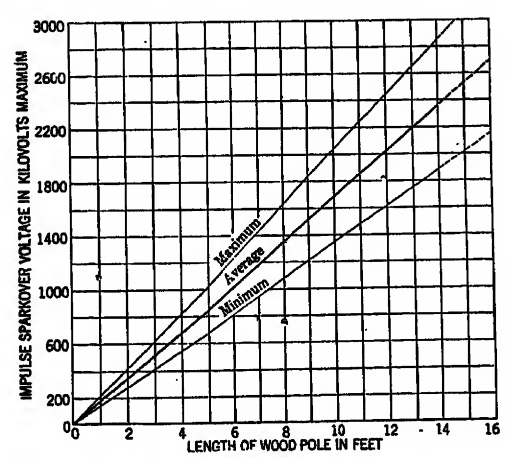

FIG. 3—SPARKOVER VOLTAGE OF WOOD POLES

Air-Gaps. Sparkover voltage measurements were made for air-gaps such as obtain between conductors and guys or grounded parts of structures and across horn-gaps, the results being given by the curve in Fig. 5.

Insulators. Fig. 6 gives the sparkover voltages for 10-in. diameter 5¾-in. spaced suspension units of the ordinary design for the 20-microsecond wave, as taken from the recent paper *Lightning* by F. W. Peek, Jr.* All tests were made with this type of unit with the exception of those using a 70-kv. pin type insulator of usual design.

*See Bibliography for references.

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Presented at the Pacific Coast Convention of the A. I. E. E., Santa Monica, Calif., Sept. 3-6, 1929. Complete copies upon request.

Combinations of Insulators, Crossarms, and Poles. Figs. 7, 8 and 9 give the average sparkover voltages for combinations of insulators with varying length of cross-arm, insulators with varying length of pole, and insulators with sections of crossarm with varying length of pole respectively. The sparkover voltage values of the

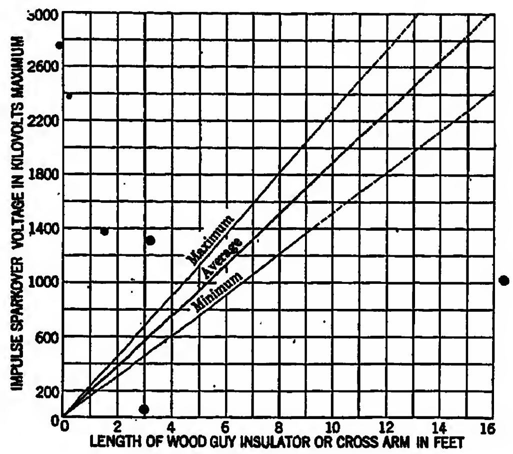

FIG. 4—SPARKOVER VOLTAGE OF WOOD GUY INSULATORS AND WOOD CROSSARMS

component parts cannot be added directly, (as will be noted) on account of the differences in the characteristics of porcelain and wood insulation and their physical relations.

If sparkover values are desired for combinations dif-

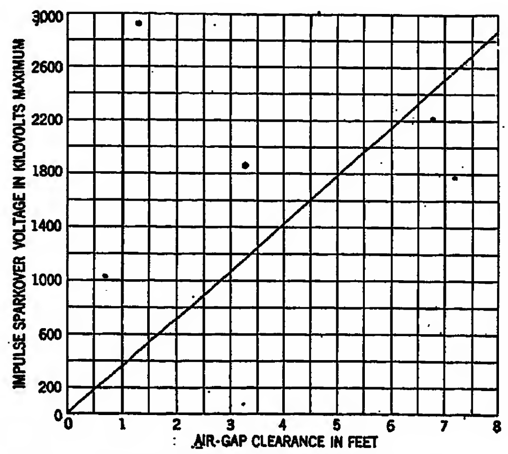

FIG. 5—SPARKOVER VOLTAGE OF AIR-GAPS

ferent than those shown or with suspension insulators with spacings other than 5¾-in., values can be interpolated by shifting the starting point of the curves or estimating from the combinations covered.

Partial Sparkover of Combinations of Insulators, Crossarms, and Poles. Sparkover of the insulators only may occur with impulse voltages applied to combinations of insulators, crossarms, and poles, at lower values than are required to completely spark over the combinations. The voltages at which these partial sparkovers occurred seemed to be primarily a function of the moisture content or conductivity of the pole or cross-arm. The intensity of the partial sparkover arc was very much lower than that for normal discharge of the lightning generator.

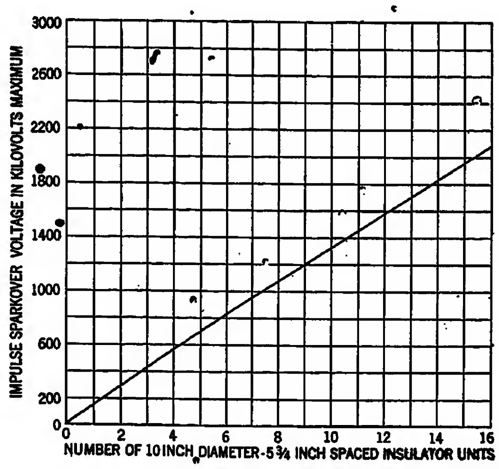

FIG. 6—SPARKOVER VOLTAGE OF SUSPENSION INSULATORS

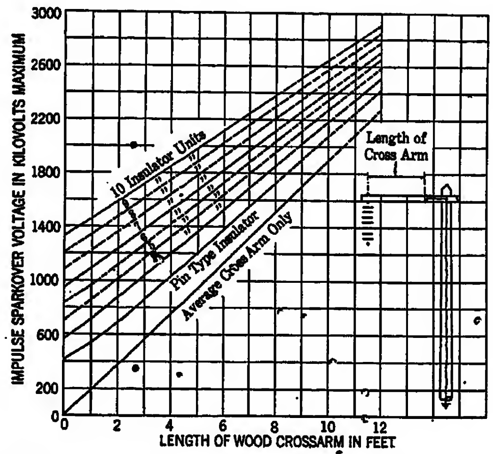

FIG. 7—SPARKOVER VOLTAGE OF INSULATORS AND WOOD CROSSARM

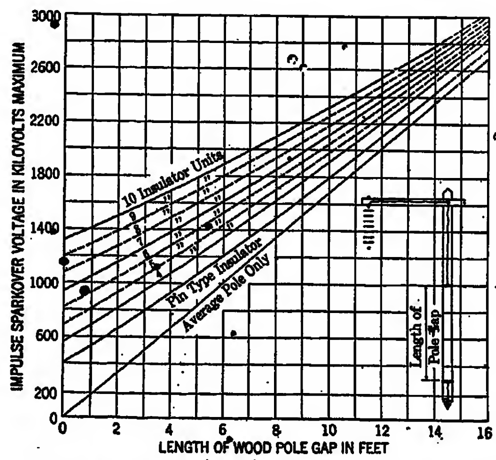

FIG. 8—SPARKOVER VOLTAGE OF INSULATORS AND WOOD POLE

The results of these tests are not included in curve form as they were very erratic, also direct practical application could not be made of the data. They did,

however, indicate possible limitations in the effective use of poles to increase the insulation of all three power conductors from ground on account of the possibility of phase to phase flashovers.

IV. Protection of Wood from Damage

A by-pass air-gap having a lower sparkover value than the section of wood being protected would seem

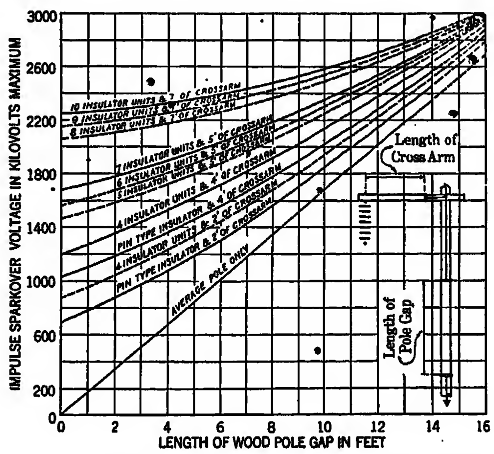

Fig. 9—Sparkover Voltage of Insulators, Wood Cross-Arm, and Wood Pole

to be an effective method of protecting wood from damage due to lightning flashover. The controlling dimensions for designing protecting horn-gaps for poles and sticks are given by Figs. 10 and 11 respectively. The "safe" air-gap dimensions are such that their sparkover values are equivalent to that of poles or

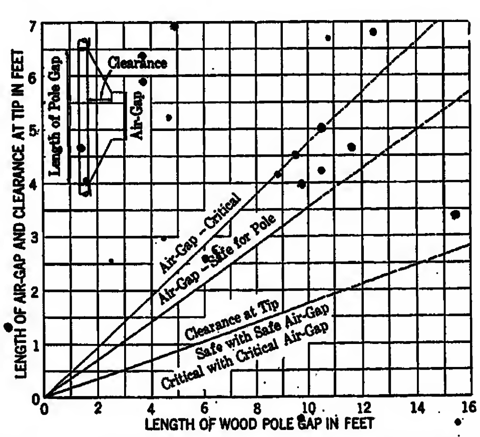

Fig. 10—Horn-Gap Protection of Wood Poles

sticks having insulation strengths equivalent to the minimum samples tested so the factors of safety obtained are dependent upon the characteristics of the particular specimens of wood. Not only must the air-gap be of proper relative length, but the clearances from all points of the horns to the wood must be such that arcs will not occur from the horns to the wood and then along its surface.

Instead of applying horns directly to guy insulators, the tests indicated that protection could be obtained by providing the by-pass gap on the pole as illustrated by Fig. 12. If damage to the pole from lightning flashover can be accepted, the "safe" curve should be used and if horn-gaps are to be applied the "critical" curve.

Protecting gaps for crossarms must be designed for each combination of insulators and crossarm length as the voltage appearing on the crossarm is dependent upon the relations in the particular combination and the

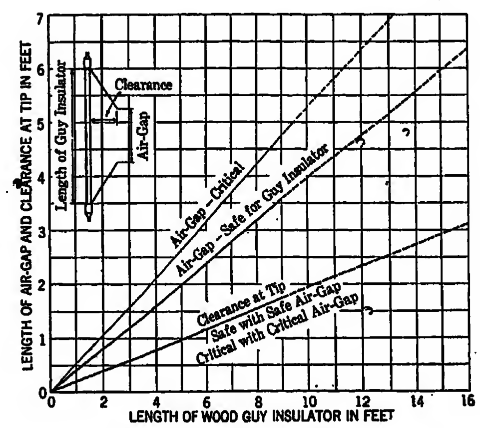

Fig. 11—Horn-Gap Protection of Wood-Guy Insulators

protecting air-gap must be so proportioned that it will have a sparkover value lower than the voltage appearing on the crossarm. Actual tests were not made to determine controlling dimensions; however, a suggested procedure is as follows: From Fig. 7 obtain the spark-

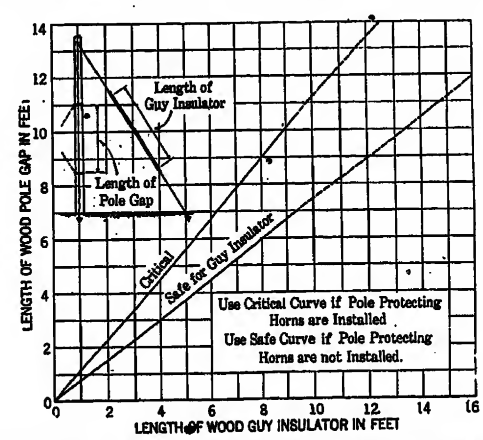

Fig. 12—Ratio of Wood-Pole Gap to Wood-Guy Insulator for Guy Insulator Protection

over voltage of the particular insulator and crossarm combination,—interpolating, if necessary; then determine the increase in sparkover voltage effected by the crossarm by subtracting the sparkover voltage of the insulators alone; take 80 per cent of the resulting value to allow for variations in crossarms, determine the air-gap length from Fig. 5, and then obtain the clearance between the horn tip and crossarm directly from Fig. 11, using the clear length of crossarm to be protected as the abscissa.

Whether protecting horns for poles, wood-guy insu-

lators, and crossarms designed with these dimensions, will be effective for actual lightning must be demonstrated by field application, or, when more is learned about lightning, including direct strokes, it may be possible to simulate more nearly the conditions in the laboratory and devise improved methods for protecting wood or modify the dimensions given by the curves.

V. Application of Data

General. This investigation should not be interpreted as a general recommendation that wood be used to increase the impulse insulation strength of lines, as it is not practicable to use wood in all localities on account of the possibility of crossarm and pole fires; it may not be desirable or effective to increase the strength of the lines materially above that of terminal equipment in all cases; the value of increased insulation as reflected in line performance has not been determined, and the use of these data must be regarded as experimental.

Several lines are now in operation, in localities where lightning is regarded as severe, on which the results of these tests have been applied. Their performance is being observed very closely and they are already yielding some interesting information. It must be remembered, however, that considerable time may be required to obtain conclusive confirming results from operating experience.

Present Conventional Designs. The data can be used for the purposes of comparing and checking the impulse insulation strengths of designs utilizing wood, correcting inconsistencies such as inadequate clearances to guys and insufficient insulation at structures where the hardware is grounded; also schemes for protecting wood may be devised for structures particularly subject to damage.

Modified Designs. Where it is practicable to have wood in the insulating circuit, and desirable to increase the impulse insulation strength of lines, the crossarms and poles may be employed to advantage in varying degrees in combination with the insulators. The crossarms can be used in designs where conventional overhead ground wires or pole grounding wires are installed. Protection from damage may be provided if there is a probability of crossarm splitting with the particular combination of insulators and crossarm. It is necessary to give particular attention to guy clearances and the insulation at special structures in order that the desired minimum insulation strength be maintained throughout the line.

The insulation strength of lines without overhead ground wires may be increased materially by the use of long wood guy insulators for increasing the insulation strengths of the guyed structures. An experimental design which has been used for 66-kv. to 132-kv. H-frame lines employs wood guy insulators about 20-ft. long. Protection for the guy insulators is provided by a horn-gap on the pole; the crossarm is protected by horn-gaps or a bonding wire is installed along the end sections of the arm to prevent splitting. It is desirable to utilize the crossarm, or at least a part of it, in order to increase the insulation between phases. All bonding and grounding may be omitted from the unguyed structures, or pole gaps with or without horn-gap protection may be installed similar to those on the guyed structures. Such designs will have impulse insulation strengths of from 2500 kv. to 3000 kv., though there is no reason why the insulation strength to ground cannot be increased considerably above these values. Ten-foot wood guy insulators have been used on several 66-kv. single-pole lines.

Insulation strengths of this order are, of course, not immune to lightning flashover nor is it possible to state the degree of improvement in service which may be realized. Surge-voltage records which have been obtained on one of the 66-kv. lines have indicated several lightning voltages in the order of the values obtained in the tests; also the schemes for protecting guy insulators have been quite successful. When more operating experience has been obtained on the experimental lines, it may be possible to make more definite statements regarding the value of wood and its protection when used as insulation for lightning voltages.

Substation Protection. Substation and apparatus impulse insulation strengths will usually be lower than that of connecting wood-pole transmission lines which have been designed to utilize the wood and therefore should be protected from surges originating on the lines. Reduced insulation, adjacent to the substations, spillway, or protective gaps, lightning arresters or combinations of these, if properly coordinated should provide the desired protection.

Conclusions

Wood has quite definite and reasonably uniform impulse insulation strength which is not materially affected by usual amounts of moisture or contamination.

It should be practicable to utilize wood to increase the impulse insulation strength of lines in many situations where there is little danger of crossarm or pole fires from leakage currents. Wood should not be used, however, as a means of reducing the amounts of porcelain insulation required to successfully insulate the normal line voltage.

Wood can evidently be protected from damage due to lightning discharges by providing a parallel air-gap of lower sparkover voltage value than the section of wood being protected.

The impulse sparkover voltages of combinations of insulators and wood are not equal to the sum of the sparkover values of the component parts.

Partial sparkover of the insulators only may occur at lower lightning voltages than are required for complete sparkover to ground, particularly when the wood is wet.

Application of these data must be regarded as experimental; also the voltage values given are for the particu-

lar test-voltage wave. Further tests would be very desirable, particularly when more has been learned about the characteristics of actual lightning and additional operating experience has been obtained from the application of the results of these tests.

ACKNOWLEDGMENTS

The tests which form the basis of this paper were conducted in the High-Voltage Laboratory of the General Electric Company under the direction of the engineering department of the Electric Bond & Share Company for the Carolina Power & Light, Florida Power & Light, and Texas Power & Light Companies.

Messrs. A. E. Silver, C. A. Jordan, and L. B. Cowgill of the Electric Bond & Share Company participated in the planning of the tests and preparation of the paper. Mr. Cowgill also assisted at the laboratory and in the analysis of the data.

The cooperation of the General Electric Company and valuable suggestions from Mr. F. W. Peek, Jr., in planning and arranging the tests as well as the assistance of Mr. W. L. Lloyd, Jr. in conducting the laboratory work are very much appreciated.

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Abridgment of

Rehabilitation of Steam Power Plants

BY C. F. HIRSHFELD[1]

Associate, A. I. E. E.

Synopsis.—Certain pertinent history of recent development in the field of power generation is given in graphic form. The problem of rehabilitation of steam power plants is shown to arise from the great rapidity of this development. While no simple rule can be given to indicate when, if at all, rehabilitation is justifiable, certain guiding criteria which may serve as aids in analysis are stated. These are followed by brief accounts of the various methods available for rehabilitating plants to different extents.

Finally, it is suggested that the possibility of later rehabilitation be taken into account when designing plants for systems in which history or argument indicate that such action is to be expected.

* * * * *

THE exceedingly rapid evolution of the art of generating electric power is known in a general way to all who have more than a casual contact with it. However, even those whose daily business consists of power generation frequently fail to appreciate the speed with which we have advanced, or the significance thereof. Among the items important in picturing the development over the past quarter century are: (1) Increase in steam pressures; (2) increase in total steam temperatures; (3) increase in physical size of boiler units; (4) increase in steaming capacity of boiler units; (5) increase in main unit turbine Sizes; (6) increase in thermal economy of plants, and (7) increase in kilowatt-hours per man hour.

The decrease in the average number of heat units utilized in the generation of a kilowatt-hour represents a remarkable procession in the direction of lower thermal costs, but we appear to be approaching the place where further improvement will be much less rapid.

Of course the decreased thermal consumption is not self-justifying, as it may have been obtained with more than a compensating increase of fixed charges. Unfortunately, experience is not yet sufficiently extensive to make possible a complete analysis. One can reason only from the reports of the few who have actually built and operated the thermally efficient plants. On such a basis and under certain conditions, they at least seem to be justified.

The kilowatt-hour generated per man hour is a subject to which little attention has been given in the literature of this subject. The increasing output per man hour is in line with the general movement throughout the industrial world. In this case, it is brought about largely through improved load factor, combined with the use of boilers and turbines of ever increasing capacity per unit. There has also been a conscious effort to design stations in such a way as to facilitate operation and maintenance and thus decrease the number of men required.

From the executive's point of view the rapid advance indicated by a study of the items listed above has had two opposing results. On one hand, the total cost of producing power has been decreased; on the other hand, the rate of obsolescence has been high, and invested capital has therefore been impaired. The net result of all the forces concerned has been a gradual but consistent lowering of the selling price of power. But the decrease in this price has naturally not been so great as it would have been had it been possible in

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1. Chief of Research Department, The Detroit Edison Co., Detroit, Mich.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

some magic way to wipe out of existence the older and less efficient plants as more modern ones became available.

The situation from one point of view is shown in Fig. 8. The solid line represents the thermal performance for a typical metropolitan system in which the rate of growth has been rapid. In drawing the line, certain liberties have been taken with facts, in that the effects of variables other than those here under consideration have been omitted. The dotted line shows what the values would have been if at the time of each improvement, all earlier equipment could have been junked and the required capacity obtained with equipment similar to that just installed. One of the problems of the executive of light and power companies is to determine from time to time just how far he is justified in moving values such as those shown by the solid lines nearer to those shown by the dotted ones. Putting it in another way, the problem is to determine from time to time that balance between production and

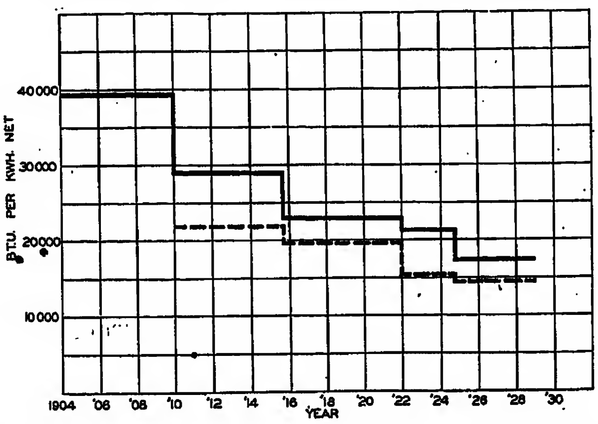

Fig. 8—The Effect of Additions to Generating Capacity on Thermal Economy of a Representative Generating System

The solid line indicates actual conditions while the dotted line shows the thermal economy which would be attained if the older parts of the system were replaced by equipment on a par with the most modern section

capital charges which will represent the best compromise for all concerned. It is out of this problem that we get rehabilitation and reconstruction of power plants.

It is self-evident that no simple rule can be set as a criterion of the advisability of such operations. There are too many variables of divergent nature. It is of course true that the old simple rule, to the effect that in the limit an improvement must at least so reduce production costs as to balance resultant capital costs, holds in a general way. But it is equally true that the effect of improvement upon both sets of costs is in general so complicated that exact calculation is very difficult, if at all possible, in any given case; and a universally applicable formula is practically non-existent. Moreover, there are frequently many almost immeasurable, although very tangible, factors that enter the problem, so that judgment must to some extent take the place of exact calculation.

There is one very interesting aspect of this problem which should be mentioned at this point. It is the difference between conditions which arise in the case of rapid and slow growth respectively. It happens that most of the light and power companies of this country have had a very rapid growth. This is a situation very favorable to the maintenance of high standards and low costs, whereas with a lesser rate of growth, the problems involved are far more complicated.

Consideration may now be given to some of the things which cause rehabilitation or even complete replacement of power plants. The more important of these are listed below:

1. The plant may be thermally inefficient in comparison with current standards of performance.

2. The plant may be inefficient in the use of man power.

3. The plant may be inefficient in its use of ground area.

4. The plant may be inefficient in its use of invested capital; such as occupying a larger building than necessary, operating boilers at low steaming rates, etc.

These simple statements should not be understood to indicate that figuratively, one can stand off to one side of the problem of rehabilitation and decide offhand with regard to the significance of these controlling factors in any given case. In each case, certain rather rough calculations will usually indicate the relative magnitudes of investments, water quantities, and areas and volumes required to obtain certain approximately determined capacities, investments, and thermal performances. Such preliminary calculations will then indicate the impracticability or even the absolute impossibility of certain solutions, leaving a much restricted field for more intense study.

It is practically impossible to set down definite rules or even guides regarding the rehabilitation of steam power plants. A few outstanding facts may, however, be indicated.

In most cases, both improvement of thermal efficiency and increased capacity will be possible, and it is necessary at the start of the problem to consider which of these possibilities, if either, is to be favored. In general, increase of capacity beyond certain limits will be attainable only by sacrificing certain thermal possibilities and a clear picture of the relative importance of the two will assist greatly in steering a reasonable course through the maze of things that might be done. Usually, the possibility of increased capacity should be given first consideration because certain limits to such increase are so easily discovered.

Thus, it would naturally be foolish to consider increase of capacity if the increased output could not be transmitted or distributed from the site in question. In many cases the available number of routes is limited and these may be found to be used to the limits of their respective capacities. Naturally this is logically the first matter for study.

If the power could be got away if generated, the next logical step is a study of those things which may limit ability to generate on that particular site. These

would be primarily the quantity of water available for condensing purposes and the possibility of delivering the required amount of fuel. If all available water is now being used, as determined either by the supply or the size of canals that must be used, increased output can be obtained only as the steam rate can be reduced, or as the vacuum is permitted to become poorer and the thermal efficiency proportionately sacrificed.

If the water and fuel supply appear adequate, the area of the site and area and cubical content of buildings come into consideration. Any of these may place unfortunate limitations on increase of capacity, but they are in general not so controlling as the other factors just considered.

Finally; the adequacy of existing switching equipment should be given attention. Any scheme which will permit the use of existing equipment would naturally stand a better chance of financial justification than one which required complete rebuilding of the electrical end of the plant.

With such possible limitations clearly evaluated, the most important decision in the average case, and that on which all else may be said to hang is whether the boilers are to be retained or scrapped. If they are to be retained, the operating steam pressure is limited to its earlier value except in those cases where a high-pressure unit is installed as an addition to existing equipment. If the boilers are to be retained, there is definite restriction of choice as to what may be done; on the other hand, there is the certainty of a smaller expenditure.

There has been much misunderstanding of the significance of high steam pressure. It so happens that a very rapid improvement in the thermal efficiency of power plants has occurred during the same time that we have been stepping up steam pressures. As a result, many who are not familiar with all the details have come to assume that the first is entirely the result of the second. This is really far from a complete statement of the facts.

During the same interval, we have increased the boiler room efficiency from values falling between 70 and 78 per cent up to values falling between 84 and 89. A change from 78 to 88 represents a fuel saving of over 11 per cent.

We have also adopted the regenerative cycle of operation, that is, heating of the feed-water in steps by means of steam bled from the turbine. This represents a saving varying from 5 per cent to 11 per cent when referred to the coal pile.

It should also be noted that, in addition, we have increased the total steam temperature. In a period of about 15 years we have gone from a total temperature of about 600 deg. fahr. to a total temperature of about 725 deg. fahr. This change of temperature is equivalent to a thermal improvement of between 4 and 5 per cent for the plant as a whole. During all this time the design of the steam turbine itself has been so improved as to result in a material reduction in heat consumption at any given pressure, temperature, and vacuum.

It is therefore apparent that it is not correct to attribute all of the improvement in the thermal performance of the past ten years or so to increasing steam pressures since many other factors have contributed. As a corollary, it follows that in the rehabilitation of a station, it may be possible to do much that will result in improvement of the thermal efficiency even though the original steam pressure must be retained.

The decision with respect to the use of higher steam pressure is not confined entirely to its effect upon the thermal efficiency, because increased capacity can be obtained in this way through the use of comparatively small high-pressure turbines discharging into the old turbines, utilizing the old condensers. Therefore, while the boiler room investment would necessarily be high, this may be balanced by a comparatively small turbine room investment. Also, the use of the old generators would make it possible in general, to use the old switching equipment, although there would naturally have to be additions to take care of the generators of the new high-pressure turbines.

Thus far the majority of cases of rehabilitation have fallen in the class in which the old boilers are retained, thus accepting the limitations set by the original steam pressure. At present, these are the more interesting and probably the more important.

The following methods of attack are available in such cases:

1. The boiler room efficiency may be greatly improved without materially increasing the steam generating capacity. This can be done by the use of more modern fuel burning equipment of one sort or another, by the addition of economizers or preheaters, or both, and occasionally, by improved baffling of the boilers.

2. The boiler room efficiency may be greatly improved, and at the same time, the steam generating capacity may be increased to a very great extent. It is not at all impossible to double or more than double the steam output of an old boiler room by using improved combustion equipment of greater fuel burning capacity, while at the same time bettering the boiler room thermal efficiency through the use of economizers or air preheaters, or both. It will be found generally advisable to use a certain amount of furnace wall cooling in such extreme cases so as to gain the increased output most easily and hold in check the tendency toward increased furnace maintenance. In this connection it should be noted that frequently it is possible to obtain greatly increased furnace volume by ignoring existing floor levels and utilizing modern ash handling equipment which requires little height for its installation.

3. The turbine room efficiency may be increased by raising the steam temperature. This will naturally involve more superheater surface, or at least differently located surface. In most cases the use of some sort of

radiant superheater in series with the older superheaters will be found advantageous, but a careful study of pressure drop through superheaters and connections must always be made. This is of particular importance when the steaming capacity of the boilers is also increased. The adoption of higher superheat will usually involve minor rebuilding of the high-pressure end of the turbine, and in some cases, major rebuilding of that end.

4. The turbine room efficiency and capacity may be increased by several different methods. The most obvious but usually the most expensive is by the installation of new, larger, and more efficient turbines taking steam at higher temperature from a boiler room of increased steaming capacity. When this method is adopted, it becomes comparatively easy to introduce regenerative feed heating, because the new turbine casings will be supplied with bleeder outlets. Therefore the improvement of thermal efficiency from regenerative heating can readily be obtained. Larger condensers or additions to existing condensers may have to be provided. The old electrical switchgear can sometimes be used by adopting a double winding on the generators so that the capacity per switch is held within the old limitations.

A less obvious but very effective method of obtaining increased capacity and efficiency is found in the compounding of old turbines with new turbines. At first glance this would appear to be practically impossible without raising the steam pressure, but this is not the case; two old turbines may be rebuilt to receive steam at lower pressure and temperature than they did before, and thus serve as low-pressure elements to a single new turbine taking steam at boiler pressure. In such cases, the extent to which regenerative heating of feed is obtainable will depend upon the design of the casings of the original turbines; naturally the new turbine can be designed for bleeder nozzles, and the exhaust connection between it and the older units can be tapped for feed heating. This general method can be made to yield an increased generating capacity of at least 50 per cent and a marked improvement of over-all efficiency as well.

Even when neither of the methods just considered is available, it is still frequently possible to obtain increased output by rebuilding the old turbines and generators. No exact values can be given, but increases of the order of 15 to 20 per cent, and occasionally even more, can be obtained in this way, while at the same time materially improving the over-all thermal performance of the station.

5. Even though it may prove economically undesirable to replace or to rebuild the old turbines, it is still frequently possible to gain marked thermal improvement over that which is to be obtained in the boiler room. This can be done through modification of the auxiliary power supply and the heat balance of the station. One is inclined to think of regenerative feed heating as necessarily tied to the bleeding of each main unit. In fact, to a certain extent it is obtained whenever that steam which is used for heating feed water has done useful work before being used for this purpose. From the thermal standpoint, it is most perfectly obtained when the steam has done the greatest amount of work before being used for heating, and when the heating is done in the greatest number of temperature steps. Practically two, or at the most three, steps will ordinarily prove economically the best with moderate steam pressures, such as one would expect in plants now being rehabilitated.

The fact that comparatively small turbo generators can now be obtained with steam rates which compare very favorably with those of their larger brothers opens up possibilities of effective regenerative feed heating, even when the main units are not equipped with bleeder nozzles. Thus, a new unit equipped for bleeding very great quantities of steam may be used to supply auxiliary energy and such part of the station output as may be necessary to produce the required amount of steam. The steam bled and exhausted from this unit may then be used for regenerative heating of the condensate from all main units. Thermally, the result would be the same as that attainable through bleeding of the main units if the steam rate of the small unit were the same as that of the larger. Practically, the result will generally not be quite so good because of the higher steam rate of the small unit.

It is worthy of note that rehabilitation of the sort which greatly increases station capacity will generally result in a radical reduction of investment per unit of capacity. It is not at all uncommon to obtain the increment capacity at from four to six tenths of the investment characteristic of the original station. On the other hand, the rebuilt station is generally more crowded than the original, and operating facility may have been sacrificed to a certain extent in producing it. The reduction of man hours per unit of station send-out which should follow the increased capacity may therefore be partly counterbalanced through having to use more men than would be used in a new station of similar unit sizes.

It is true that some executive engineers do not accept rehabilitation as economically justifiable in their own systems. Therefore, it is not legitimate in all cases to predicate original station design on the assumption that rehabilitation will be a necessary part of the history of the plant. However, such rebuilding to a greater or lesser extent appears to be becoming more general than it once was and the history of any given system with respect to such practises should be given serious study when designing new plants for that particular system. If it has been one in which rehabilitation has been found economically desirable it is obviously the part of wisdom to design rather generously with respect to ground area, floor area, cubical contents, and clearances, so that if and when rehabilitation becomes necessary there may be the greatest degree of flexibility.

Abridgment of

Effect of Color of Tank on the Temperature of Self-Cooled Transformers under Service Conditions

BY V. M. MONTSINGER*
Fellow, A. I. E. E.

and

L. WETHERILL*
Associate, A. I. E. E.

Synopsis.—The effect of color on the temperature of oil-immersed self-cooled transformers under service conditions has been a mooted question for a great many years. Based upon the relative absorption powers of the various colors often used in painting transformer tanks, the lighter colors should give appreciably lower temperatures in hot climate sections. The results of three series of field tests conducted on actual transformers are given in the paper. The results, however, do not show the advantages for the light colors that would be expected, based solely upon the absorption powers of the colors.

A method of calculation is used to check the test results, taking into consideration the various factors which apply to a transformer and do not apply to, say, a piece of metal painted and exposed to the sun's rays; i. e. the ratio of the area of the surface exposed to the sum to the total surface dissipating heat, the difference in thermal capacities, and the condition where in one case the test piece is dissipating heat as well as receiving heat from the sun, whereas in the other case it only receives heat from the sun. It is shown that when all the factors are taken into consideration, the calculated results check the observations very closely. Finally, it is shown that the selection of color for repainting transformer tanks exposed to the sunshine should be based primarily on durability and appearance rather than upon color, since the difference in temperature resulting from a tank painted black and aluminum, or even white, will seldom exceed one or two deg. cent.

I. General

The predetermination of the ultimate temperature rise of a transformer operating in the shade with constant load and ambient conditions is a comparatively simple problem.

Also, the effect of color on the temperature rise under these conditions can be calculated, knowing the emissivity of the color and the percentage of losses dissipated by radiation and convection for a given color.

In service, however, we have a more complicated set of conditions to deal with, making it more difficult to predict the effect of color on the temperature of transformers. For example, only a part of the tank's surface is exposed to the sun's rays. The part exposed is absorbing heat while the part unexposed is not affected by the sun's rays. The tank is exposed only a part of the time—during the day,—while at night conditions may be altered; *i. e.*, some surfaces that are advantageous in the sunshine are disadvantageous in the shade. Also, the solar intensity varies during the day, which complicates the problem still further.

The impression is prevalent that a transformer tank, if painted with a light color, will operate at an appreciably lower temperature in the sunshine than if painted black. This impression is based upon either the relative absorption powers of the colors or tests made on apparatus under conditions not applicable to transformer conditions.

All tests which have been made on transformers under service conditions show, however, that the gain resulting from painting the case a light color is hardly worth considering.

The objects of this paper are, (1) to give the results of the available field tests, and (2) to reconcile the results of these tests with theoretical results; in other words, to show by a method of calculations that we should not expect an appreciable gain from the light colors for conditions under consideration.

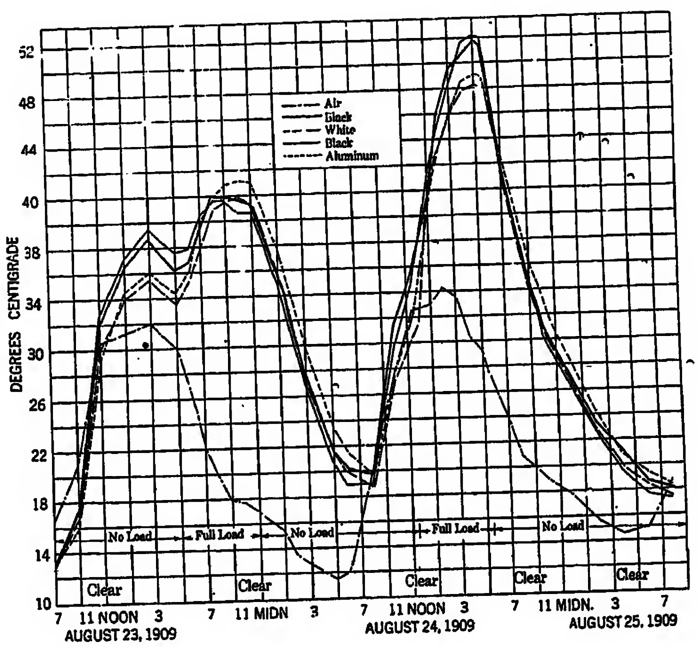

Fig. 3—Effect of Sun upon Heating of Transformers of Different Colors

Normal excitation—six-hour full-load
5-kv-a. transformers with plain tanks. Temperature by thermometer in top oil. Tests made in Pittsfield

II. Results of Tests Made Under Service Conditions

Three series of tests made under service conditions (at Pittsfield, Mass., Fresno, Calif., and Dallas, Texas) are given and analyzed:

Pittsfield Tests. In 1909 a series of tests was made

*Both of the General Electric Company, Pittsfield, Mass.

Presented at the Pacific Coast Convention of the A. I. E. E., Santa Monica, Calif., Sept. 3-6, 1929. Complete copies upon request.

at Pittsfield, Mass. Some 5- and 50-kv-a. lighting transformers were tested in an exposed location. Tests were made with tanks painted black, white, and aluminum. The transformers were loaded by the

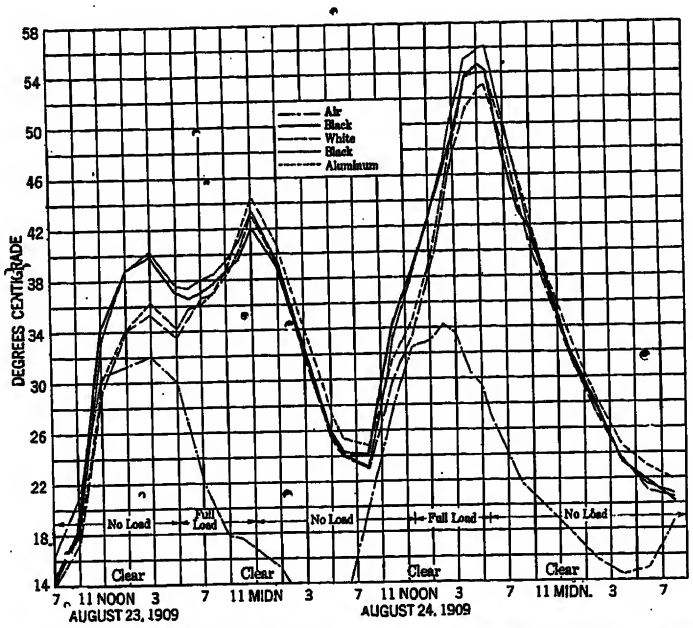

Fig. 4—Effect of Sun upon Heating of Transformers of Different Colors

Normal excitation—six-hour full-load
50-kv-a. transformers with cast iron corrugated tanks. Temperature by thermometer in top oil. Tests made in Pittsfield

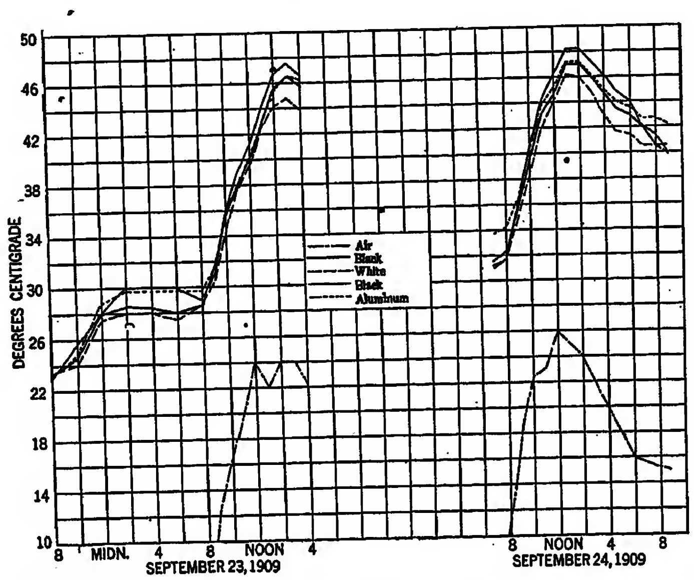

Fig. 5—Effect of Sun upon Heating of Transformers of Different Colors

Continuous full load
5-kv-a. transformers with plain tanks. Temperature by thermometer in top oil. Tests made in Pittsfield

"loading back" method, which insured equal loads on all pairs.

Figs. 3 and 4 show the results of tests made with six-hour full load following normal excitation at 5 p. m. and 11:30 a. m. The effect of the color is not very great, the maximum difference occurring at 4 p. m. showing only 3 deg. cent. in favor of white paint over black.

Fig. 5 shows the result of a continuous full-load run. The difference in temperature is still less, the maximum difference being about 2 deg. cent.

Fresno Tests. In 1922 Messrs. Moore and Moulton

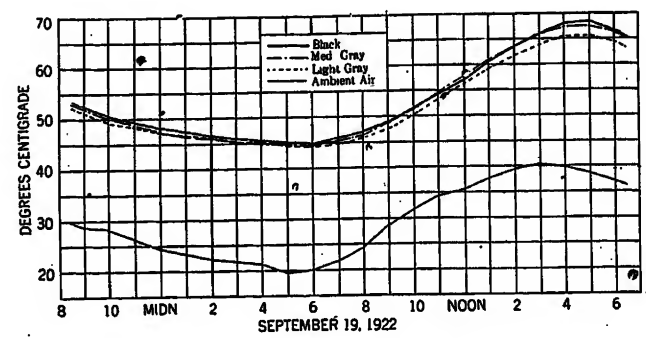

Fig. 8—Effect of Sun upon Heating of Transformers of Different Colors

Normal excitation—normal load
Three-kv-a. transformers with plain cases. Temperature by thermometer in top oil. Tests made in Fresno, California

of the San Joaquin Light and Power Corporation conducted a long series of tests[1] on several 3-kv-a. lighting transformers, in the sunshine at Fresno, Calif., where the air reached a maximum temperature of 38.8 deg. cent. (102 deg. fahr).

Fig. 8 shows data for full-load runs. The following average temperatures were observed during a 24-hr. period starting at 8 p. m., September 19.

Color of case	Average ambient		Transformers with normal load temperature rise over air			
			Deg. fahr.		Deg. cent.	
	Deg. fahr.	Deg. cent.	Avg.	Max.	Avg.	Max.
Black	85.5	29.7	43.3	53.2	24.	29.5
Medium gray	85.5	29.7	42.5	52.1	23.4	29.0
Light gray	85.5	29.7	41.0	48.6	22.8	27.0

Many more tests were made than shown above. However, the general results were the same.

The following comments are from the report by Moore and Moulton on these tests. They will be of interest since they were made by operating engineers who have transformers operating in one of the warmest sections of the United States.

"The number of successive days during which tests were made and the consistency of the results leaves little doubt as to the accuracy of the full-load tests. The fact that a gray paint will not reduce the oil temperature more than 3 or 4 deg. fahr. or 1 or 2 deg. cent. during the extremely hot weather encountered in the San Joaquin Valley seems established. This was a disappointment in view of the seemingly prevalent

1. See Bibliography for references.

belief that a much larger reduction for gray paint would be found.

"We have reached the conclusion, after a very careful study of the results herein recorded, that any additional expenditure to procure a gray case instead of black would not be justified. This is in view of the fact that the differences in temperature under full load conditions do not vary any more than the difference obtained from various makes operating under identical conditions. Assuming that gray or black tanks are available at equal cost, and that experience shows that gray paint stands up in service as satisfactorily as the black, we should be inclined to favor the medium gray tank. We feel very strongly however, that any expenditure to repaint black cases now in service would not in any way be justified."

Dallas Tests. Through the courtesy of O. S. Hockaday of the Texas Power and Light Company, the writers are enabled to give the results of a series of tests conducted in 1924 on three 150-kv-a. transformers with corrugated tanks painted different colors and exposed to the sun's rays. To calibrate the transformers with reference to each other, temperature of each transformer was recorded every day to 6:00 p. m. for about a month with the standard paint (aluminum with black top and bottom) on all three tanks. The average reading for each transformer showed that the northeast unit ran 1 deg. cent. cooler than the middle one and the southwest unit ran 0.3 deg. cent. cooler than the middle one.

The northeast unit was then painted all aluminum, the middle unit all black, and the southwest unit left with aluminum with black trimmings. The average results of the readings taken from July 25 to September 17 are given below; as in the calibrating run, one reading was taken at 6 p. m. each day; fair weather occurred during 80 per cent of the test period.

From July 25 to September 17 inclusive the average temperatures were:

	Northeast all aluminum	Middle all black	Southwest alum. black trim.
Observed temperature........	47.7	49.6	49.1
Correction from calibrating run	1.0	0	0.3
Corrected temp. (deg. cent.)..	48.7	49.6	49.4

Thus the all-aluminum runs 0.9 deg. cent. cooler than the black.

That the 20 per cent of cloudy or rainy weather has not had any great effect can be seen from the following set of figures, based on seven consecutive days of fair weather.

From August 6 to 12 inclusive the average temperatures were:

	Northeast all aluminum	Middle all black	Southwest alum. black trim
Observed temperature........	49.1	50.4	50.1
Average correction from calibrating run...............	1.0	0	0.3
Corrected relative temp... ...	50.1	50.4	50.4

In this case, the all aluminum runs 0.3 deg. cent. cooler than the black.

Table I gives the results of reading taken October 1 every half hour from 10 a. m. to 6 p. m. Based on the average readings corrected, the all aluminum tank ran 0.7 deg. cent. cooler and the aluminum-black trim ran 0.5 deg. cent. warmer than the all black tank. This last set of readings is perhaps the most reliable since it took account of the entire day and afternoon when the aluminum color shows up to best advantage.

TABLE I

TESTS MADE BY TEXAS POWER AND LIGHT COMPANY

Three Transformers–150 Kv-a., Corrugated Tanks, Bank Capacity 450 Kv-a.

Time	Kv-a.	Ambient temperature	Transformer temperature: Aluminum	Black	Alum. black trim.
10:00 a. m.	394	23	31	33	32
10:30	394	23	31	34	33
11:00	396	23	32	34	33
11:30	425	24	33	35	34
12:00 m.	445	25	34	36	35
1:00 p. m.	360	27	36	37	37
1:30	343	28	36	38	37
2:00	373	29	37	38	38
2:30	370	29	37	38	38
3:00	365	29	38	39	38
3:30	357	29	38	39	39
4:00	324	28	39	40	40
4:30	321	27	39	40	40
5:00	376	26	38	40	39
5:30	384	24	38	40	39
6:00	374	22	37	39	39

Data furnished through the courtesy of O. S. Hockaday of the Texas Power and Light Company.

Pittsfield Tests on Aluminum Tanks. The preceding tests showed a slight advantage for aluminum but they were made under circumstances favorable to aluminum. Tests made with the tanks shaded from the sun show the disadvantages of aluminum.

Some tests were made in Pittsfield in 1925 to show the effect of aluminum paint on operation in the shade (indoors) on two standard 25-kv-a. transformers, having plain cases.

Two units having the same losses were first tested with their tanks painted black. The two tanks were then painted aluminum and the test repeated with results shown below.

Transf. No.	Room temp. deg. cent.	Top oil rise deg. cent.: Black	Alum.	Max. tank surf. rise deg. cent.: Black	Alum.
1	26	37.2	46.3	32.5	41.0
2	26	36.7	47.6	32.0	41.6
Average	26	37.	47.	32.3	41.3

The oil rise of the aluminum tank was 126.5 per cent of the black tank. The maximum tank surface rise of the aluminum tank was 126 per cent of the black tank. This checks very well the estimated percentage of about 130 per cent, assuming a low temperature emissivity of 0.55 for aluminum paint.

The effect of aluminum paint in increasing the temperature indoors is lessened on radiator and tubular tanks, but may still be appreciable. A tank with four rows of tubes will run by calculation about 12 per cent hotter with aluminum paint when operating in the shade. Even on the largest tanks with radiators as close to each other as possible, it is estimated that aluminum paint will increase the temperature rise about 7 per cent when operating in the shade.

III. Calculation of Effect of Color

The thermal behavior of a transformer operating in the sun under variable conditions can be calculated quite accurately using a point by point solution. Two cases are worked out in the complete paper. The results of the first case are shown in Fig. 12. The behavior of the black transformer was used as a base to determine the effect of the sun, for use in calculating the behavior of the white transformer.

*TABLE II

LOW TEMPERATURE TOTAL EMISSIVITIES

Silver, highly polished	0.02
Platinum " "	0.05
Zinc " "	0.05
Aluminum " "	0.08
†Monel metal, polished	0.09
Nickel "	0.12
Copper "	0.15
Stellite "	0.18
Cast iron "	0.25
Monel metal, oxidized	0.43
Aluminum paint	0.55
Brass, polished	0.60
Oxidized copper	0.60
Oxidized steel	0.70
Bronze paint	0.80
Black gloss paint	0.90
White lacquer	0.95
White vitreous enamel	0.95
Asbestos paper	0.95
Green paint	0.95
Gray paint	0.95
Lamp black	0.95

*These data are the result of investigations made by the Bureau of Standards, the British National Physical Laboratory, General Electric Research Laboratories, and several eastern universities, and were collected by W. J. King of the General Electric Co.

†Questionable because of scant or inconsistent data.

*TABLE III

COEFFICIENT OF ABSORPTION OF SOLAR RADIATION

Silver, highly polished	0.07
Platinum " "	0.10
Nickel " "	0.15
†Aluminum "	0.15
Magnesium carbonate	0.15
Zinc oxide	0.15
†Steel	0.20
Copper	0.25
White lead paint	0.25
Zinc oxide paint	0.30
Stellite, polished	0.30
Light cream paint	0.35
Monel metal, polished	0.40
Light yellow paint	0.45
Light green paint	0.50
Aluminum paint	0.55
Zinc, polished metal	0.55
Gray paint	0.75
Black matte	0.97

*These data are the result of investigations made by the Bureau of Standards, the British National Physical Laboratory, General Electric Research Laboratories, and several eastern universities, and were collected by W. J. King of the General Electric Co.

†Questionable because of scant or inconsistent data.

IV. Conclusions

A. In Shade. 1. The temperature rise of a transformer in a tank painted with a non-metallic paint is practically independent of the color.

2. Metallic paints radiate less heat than non-metallic paints and may cause a transformer to overheat.

3. A plain aluminum painted tank will run approximately 30 per cent higher temperature rise* than if painted with a non-metallic paint.

4. Thirty per cent represents the maximum increase of temperature rise caused by painting a tank with aluminum instead of a non-metallic paint. If a plain tank is finished with a surface having a lower emissivity than aluminum the temperature increase naturally will be more than 30 per cent, increasing to about 75 per cent* where the emissivity is very low such as for polished silver, nickel, etc.

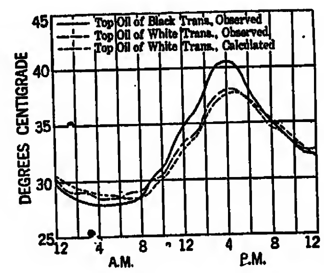

Fig. 12—Comparison of Top Oil Temperature of 50-Kv-a. Transformers Operating in Sun

5. As the surface of a tank becomes more and more convoluted, (with tubes and externally connected radiators) the effect of a metallic paint in increasing the temperature rise becomes less and less, in extreme cases getting as low as 7 per cent.*

B. In Sunshine. 1. The improvement resulting from using special paint on self-cooled transformer tanks, either plain or with convoluted surfaces, is in service very small, hardly enough to be worth considering. Even under the most favorable conditions (white lead paint, smooth tank surface, and a hot, sunny day) the gain is not more than 2 deg. cent. average during a 24-hr. period and in some cases less than 2 deg. cent.

2. The repainting of transformer tanks in the field for operating in the warmer sections of the country should be based upon the consideration of durability and appearance rather than upon color.

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Abridgment of

Electrical Machinery

ANNUAL REPORT OF COMMITTEE ON ELECTRICAL MACHINERY*

To the Board of Directors:

The Committee on Electrical Machinery has functioned under an organization similar to that of last year; that is, with subcommittees commissioned to handle all the matters of a particular type of equipment that properly belong to this committee.

After reviewing the proposed standards of the I. E. C. on "Rating of Electrical Machinery", the committee recommended agreement with the International Standards in a number of items, but recommended against the adoption of higher temperature rise for organic insulation,—particularly for transformers,—and against a few other features in which European practises differ radically from those in America.

In the new report for transformer standards there is included an appendix designed to outline operation by temperature rather than rating, which reduces hot-spot temperature from 105 deg. to 95 deg. whenever the ambient is 30 deg. cent. or less. Standards for constant-current transformers have been completed and presented for review.

There is evidence of a misunderstanding of "conventional" efficiencies and losses that are neglected in slow-speed engine-driven machines, on the part of engine builders who sometimes charge against the generator much larger losses than actually exist. Steps have been initiated to clarify this situation and to modify the standards to include these small losses.

Work has been started on the development of standards for a-c. commutator motors, and studies have been undertaken to establish a reasonable allowance for no-load losses when these are not determined by test.

Mercury arc rectifiers have been actively studied and records of their performance assembled. Ground work for the preparation of standards for this equipment and the special transformer requirements has been well laid.

The committee has been commissioned with the preparation of a test code for certain types of apparatus, and it is expected that this will be the beginning of the development of an extensive test code outlining generally accepted methods of test.

No radical departure in the size or design of apparatus has been evident during the past year, but there has been a gradual upward tendency in ratings and efficiencies. In some lines, factory methods are rapidly being changed by the substitution of structural and rolled steel parts for castings and it is expected that these changes will be reflected more obviously in designs as advantageous modifications become evident. While the maximum nominal operating voltage has not been extended beyond 220 kv., the upward trend in voltage has been evident in large equipment. More specifically, some of the trends and typical examples of recent developments are outlined in the following paragraphs.

TRANSFORMERS

While apparently well stabilized in types of construction, transformers have increased in size, and their small margin of losses has been further reduced. Efficiencies have been obtained as high as 99.71 per cent in a 60-cycle auto-transformer with 2—1 voltage ratio and 99.54 per cent in a 60-cycle two-winding transformer. Manufacturer's testing facilities have been increased until the General Electric Company can secure 5,000,000 volts with its lightning generator at Pittsfield, and the Westinghouse Company Laboratory is capable of producing over 3,000,000 volts.

The General Electric Company has developed a new type of transformer which has been called "non-resonating." Published tests indicate that in the "non-resonating" transformer the voltage distribution is approximately uniform and the same for high-frequency impulses as it is for operating frequencies. These results are obtained by the use of special shields connected to line terminals but external to the windings so that the necessary charging current can be supplied directly to the various coils rather than indirectly through line end coils. The first of the "non-resonating" transformers has been in operation about two years.

The use of load-ratio control has materially increased

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Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

and the manufacturers have reduced dimensions so that they may now be secured on the transformer tanks extending but little beyond the radiators. The same type of equipment in conjunction with regulating transformer windings may be used to obtain phase control.

Forced air ventilation supplementing self-cooling is particularly effective in large self-cooled units in decreasing the radiator surface required for maximum rating without requiring blower losses on moderate ratings. Two types of equipment are furnished, one of which consist of a single blower, piped to all radiators, and the other, small individual blowers and housings with one attached to each radiator.

Three-winding transformers have continued in popularity, and the Westinghouse Company reports that nearly half the power transformers ordered of its company in 1928 were of this type.

Typical of the most notable installations of large units may be mentioned the following:

An 83,333-kv-a. output, three-phase, 25-cycle water-cooled auto-transformer was installed by the Buffalo General Electric Company, (furnished by the General Electric Company) and probably concentrates in one unit the largest kv-a. output so far undertaken. The high-voltage windings consist of two windings, each of which is connected to a separate bus section and so arranged that a short circuit on one winding tends to raise the voltage of the other.

The largest self-cooled transformer reported consists of 40,000-kv-a. three-phase 60-cycle transformers supplied to the United Electric Light and Power Company of New York by the Westinghouse Company.

Six single-phase 15,000-kv-a. water-cooled 25-cycle transformers, with a voltage ratio of 220/110/132 kv. with both low-voltage windings of full capacity, were supplied to the Hydro Electric Power Commission of Ontario by the Canadian Westinghouse Company and are probably physically the largest 25-cycle units yet supplied.

Single-phase self-cooled transformers, with ratings of 33,333 kv-a. per transformer, self-cooled and 43,333-kv-a., with auxiliary air blast, have been installed at the Plymouth Metering Substation of the Philadelphia Electric Company and were supplied by the Westinghouse Company. They are three-winding transformers with 220-kv. high voltage and are equipped with load ratio control.

Low cost, small power supply from high-voltage lines, has been made available by the standard "substation" for use on 66,000-volt grounded neutral system with a capacity of 15 to 50 kw.-single-phase. The unit consists of an over-insulated single-bushing transformer with cut-outs, metering equipment, etc.

Synchronous Machines

The tendency toward larger machines has continued in the field of waterwheel generators, but there has been no increase in size of turbo generators beyond those previously reported. The use of fabricated construction has been extended considerably, and the frames, bearing brackets, and rotor spiders of practically all machines are built up from steel plates and rolled members.

The use of quick-response excitation has increased, and the rates of changes of exciter voltage that are now available are in excess of those required for most operating conditions. More experience has been obtained with hydrogen-cooled condensers, to which type of machine this method of cooling is particularly applicable. The designs of high-voltage machines has been advanced, and several generators have been built by the General Electric Company to operate at 22,000 volts; the Westinghouse Company also is now building a 75,000-kv-a. 23,000-volt generator. The scheme of using two independent parallel windings has been supplied by the General Electric Company in two large alternators allowing each winding to be connected to different bus sections so that the reactance between the windings acts as a bus reactor between bus sections.

Hydraulic Generators

Four waterwheel generators, larger than any yet built, were ordered from the General Electric Company by the Dnieprostroy Hydro-Electric Development of Russia. Fabricated construction will be used in all principle parts of the units.

The following lists the more important machines ordered or installed during the past year:

Purchaser	No.	Kv-a.	Speed	Manufacturer
Dnieprostroy Hydro-Electric Dev.	4	77,500	88.2	G. E.
Lexington Power Co.	4	40,625	138	West
Phila. Elect. Co.	4	40,000	81.8	G. E.
	3	40,000	81.8	West
New England Power Co.	4	39,000	138	West
Brazilian Hydro-Electric	1	33,000	125	G. E.
Southern Calif. Edison	1	35,000	375/450	G. E.
Alabama Power Co.	2	29,000	100	West
Norwood Electric Co.	2	27,500	90	A. C.
City of Los Angeles	1	25,000 (Hor)	143	A. C.
Montana Power Co.	2	25,000	81.8	West
Norwood Electric Co.	1	22,500	71	A. C.

The vertical Westinghouse and Allis Chalmers units are of the so called "umbrella" or "overhung type" with the guide and thrust bearings located under the generator rotor. This scheme is especially suited to machines whose diameter is large compared to the height. The Conowingo units have been installed since last Spring. Tests on the General Electric Company units showed an efficiency of 97.99 per cent.

Westinghouse has brought a new line of small generators with structural steel parts in ratings from 62.5 kv-a. to 3000 kv-a. at speeds from 100 to 400 rev. per min.

Steam Turbine Generators

There were no orders placed this year for any exceptionally large units although a number of orders were received for machines ranging from 60,000 to 75,000 kw.

The use of fabricated parts has been extended and some units have been designed so that the change to hydrogen cooling may be added at a later date. Some of the units mentioned in last year's report have been installed and are in operation. Among more notable installations are the following:

Purchaser	Kv-a.	Speed	Voltage	Shaft	Manu-facturer
State Line Gen. Co.	235,000	1800	22,000	3	G. E.
United Elec. Lt. & Pr. Co.	188,400	1800	13,000	2	West
United Elec. Lt. & Pr. Co.		LP 1200			
	188,250	HP 1800	13,800	2	A. B. B.
Amer. Gas & Elec. Co.	187,000	1800	11,000	3	G. E.
N. Y. Edison Co.	160,000	1500	11,400	1	G. E.
Brooklyn Edison Co.	137,500	1800	13,800	2	West
So. Calif. Edison Co.	100,000	1500	16,500	1	G. E.
Union Elec. Lt. & Pr. Co.	83,333	1800	13,800	1	G. E.

The Westinghouse Company has built a 12,500-kv-a., 3600-rev. per min. generator with self-contained double-entrance fans, which design is said to materially increase its efficiency.

Synchronous Motors

The design of synchronous motors has been advanced in securing higher efficiency and better torque characteristics and there has been an increase in the use of these machines for industrial purposes.

The Westinghouse Company has built two 1000-hp., 180-rev. per min. motors for cement mill drive, which, while of the salient pole construction, have polyphase damper windings connected through slip-rings to external resistors for starting.

The first two-speed synchronous motors which have previously been described by General Electric Company have been put in service.

Ship Propulsion Synchronous Motors

Two ships having a displacement of a little over 30,000 tons have been placed in service and are propelled at a speed of 18 knots by two 8500-hp. synchronous motors furnished by the General Electric Company. Work has been started on electrical equipment for other large vessels.

Synchronous Condensers

The Westinghouse Company has built two 30,000-kv-a. condensers at 720 rev. per min. for the Philadelphia Electric Company, which are the largest units so far constructed at that speed.

The first commercial application of hydrogen cooling for electrical machines was made on a General Electric 12,500-kv-a. outdoor synchronous condenser at the Pawtucket Substation of the New England Power Company. A larger unit of similar design, rated 20,000 kv-a., is in operation at the Turner Substation of the Appalachian Electric Power Company. In addition to reducing losses and increasing the rating, it is believed that the hydrogen cooling increases the insulation life, and decreases the windage noises and the fire risk.

D-c. Machines

The fabrication of parts without the use of castings has been extended lately, particularly as to the rotating parts. The development of the arc-welded fabricated construction has given flexibility, and still permitted the standard part principle which is adaptable to machines of different designs and ratings.

Several installations have been made of a new scheme of ventilation in which a special volute housing is arranged to make use of the windage of the machine to force heated air through ducts out of station.

Motor-Generator Sets

The Allis Chalmers has furnished a 7000-hp. double-unit reversing mill motor to the Illinois Steel Company and a 6000-kw. flywheel induction motor-generator set for driving it. The General Electric Company has furnished some 4000-kw., 5500-kw., and 6000-kw. motor-generator sets for electrolytic work. These sets were built with one motor and two generators. The Cleveland Terminal electrification has adopted 3000-volt, 3000-kw. motor-generator sets for power supply. The General Electric sets consist of two 1500-volt generators driven by one motor having an overload capacity of 50 per cent for two hours and 200 per cent for five minutes.

Motors

An interesting application consists of five motors mounted on a common bedplate with a distance between centers of 7 ft. furnished by the Westinghouse Company to the American Steel and Wire Company for rolling mills. While this requires extreme accuracy in the speed control it permits a better product.

Gearless traction elevator motors are gaining in use for high-speed service and have been supplied as large as 140-hp. at 85 rev. per min. by General Electric Company.

The use of d-c. motors and generators for Diesel-electric ship propulsion has increased. The largest is a 4000-hp. motor supplied by two 800-kw. Diesel-engine-driven generators.

Exciters

Quick change of excitation has been applied in a number of installations to increase system stability during disturbances. Rates of voltage rise of 6400 volts per sec. with a maximum of 950 volts for a 250-volt exciter have been obtained.

Induction Motors

During the past year the most interesting developments have been in the line of small motors. The need for small single-phase motors of the highest quality

for domestic service brought renewed activity to the capacitor motor. Reliable low-cost capacitors have become available through the progress of the radio art and made capacitor motors economically feasible. The Howell Electric Company has developed a line of this type and the General Electric Company has put several thousand on electric refrigerators. The use of single-phase repulsion-start induction motors in sizes up to 10-hp. has grown steadily and a general improvement of characteristics has been obtained. The General Electric Company has brought out a new motor of this type, with square punchings and graded slots, to obtain more efficient utilization of steel.

Practically all American motor manufacturers are building an extensive line of motors designed for full-voltage starting. The great majority of these are of sizes between 7½- and 30-hp.

The use of small induction frequency-changer sets to supply moderately high-frequency power to drive high-speed motors has grown steadily.

Two induction synchronous frequency-changer sets built for the Niagara Lockport and Ontario Power Company by Westinghouse were placed in operation in 1928. Each synchronous machine is rated 25,000 kv-a., and each induction motor, 28,000 hp., making these the largest variable-ratio frequency changers in the world.

The General Electric Company is building a similar 25,000-kv-a., 27,500-hp. set for the Buffalo General Electric Company.

Enclosed fan-cooled motors have grown remarkably popular. The initial temperature rise of an open motor is not greatly increased by these features, and the accumulation of dirt in service of an open motor, with the consequent increase in temperature rise, is eliminated.

The trend towards the development of large capacity high-speed motors is indicated by some orders recently placed with the Westinghouse Company for eight 1250-hp., 3600-rev. per min. induction motors, to be used for driving high-pressure boiler-feed pumps.

Mercury Arc Rectifiers

Mercury arc rectifiers continue to hold the interest in the d-c. railroad and street railway field. Since January 1, 1928, a total of 28 sets have been installed or placed on order in this country, having a total kilowatt rating of 48,975. The majority of these sets consist of single tanks. The same general trend appears to be current in Europe as over 40 rectifiers with current ratings of 4000 to 6000 amperes were installed or placed on order.

The deleterious effects and frequency of arc-backs have been materially decreased due to more ample auxiliaries, the addition of arc suppressors and other modifications.

Graphitic anodes have given good account of themselves during the past twelve months, and confidence in metallic anodes is indicated by their continued use in the largest rectifiers now in service in this country.

The outstanding installations during the past year were two 5000-ampere, 625-volt automatic railway outfits installed on the Commonwealth Edison Company's system for railway service, having an overload capacity of 7500-ampere for two hours and 10,000 amperes for one minute. The units are six-phase, twelve-anode type with arc supressors supplied by the Brown Boveri Company. This company has developed a new type of rectifier for 3000 kw., which is about 30 per cent smaller than the original units of this capacity. Another type with normal rating as high as 16,000 amperes has been developed showing improved efficiency and reduced weight.

MERCURY ARC RECTIFIERS IN RAILWAY INSTALLATIONS INSTALLED OR ON ORDER SINCE 1927

	No. of sets	Tanks per set	D-c. voltage	Kw. per set	Total kw.	Control
Commonwealth Edison Company, Chicago, Maypole	1	1	600	3000	3000	Auto
Commonwealth Edison Company, Chicago, West Lawn	1	1	600	3000	3000	Auto
Toronto Hydro Electric System, Toronto Casington	1	1	600	1100	1100	Auto
Southern Public Utilities Corp., Charlotte, N. C., Eliza. Ave	1	1	600	750	750	Manual
City of Calgary, Calgary, Portable	1	1	575	600	600	Auto
Union Railway of New York City, New York, St. Peters Ave	1	1	625	1000	1000	Auto
Toronto Hydro Electric System	1	1	600	1100	1100	Auto
American Gas & Electric New York	2	1	600	1000	2000	Auto
Cons. Mining & Smelting Co. of Canada, Electrolitic	3	2	460/560	5600	16800	Manual
City of Edmonton			575		1325	Manual
City of Calgary	..	..	575		1200	Auto
City of Halifax	1	1	600	1100	1100	..
Chicago & Joliet	1	1	600	500	500	Auto
Columbus Railway Power & Light Co	1	2	600	500	1000	Manual
Columbus Railway Power & Light Co	1	1	600	500	500	Auto
Columbus Railway Power & Light Co	1	1	600	500	500	Auto
Eastern Mass. St. Ry	1	2	600	1000	3000	Manual
Chicago So. Shore & So. Bend Ry	1	2	1500		1500	Auto
Chicago So. Share & So. Bend Ry	1	2	1500		1500	Auto
Chicago So. Shore & So. Bend Ry	1	2	1500		1500	Auto
Philadelphia Rapid Transit	3	1	600	1000	3000	Auto
Sacramento Northern Railway	1	1	1500	500	500	Auto
Piedmont & Northern	2	2	1500	750	1500	Auto
British Columbia Elec. Ry.	1	1	600	1000	1000	Manual
					48975	

Bibliography

An extensive bibliography of pertinent developments has been compiled and was published with the complete report.

Abridgment of

Effect of Surges on Transformer Windings

BY J. K. HODNETTE[1]

Associate, A. I. E. E.

Synopsis.—A study has been made of the reaction of transformer windings in grounded neutral systems when subjected to transient voltage surges such as exist on normally insulated lines. Measurements of the voltage distribution throughout the windings between various elements and to ground were effected by means of a cold cathode type cathode ray oscillograph and sphere-gaps.

An estimate of the stresses occurring in transformers due to the voltages occurring on transmission systems is made, basing them on the most recent data obtainable. The data indicate that the worst stresses, both within the winding and to ground, are in the vicinity of the line coil.

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I. Introduction

With the rapid growth of transmission systems and their interconnection to larger systems, continuity of service is becoming increasingly more important. This has prompted a great amount of study on the subject of increased reliability of all component parts of the system. Such studies have been conducted on transmission lines and connected apparatus. The power transformer constitutes a vital link in such systems. Due undoubtedly to the unceasing research and study conducted during their rapid growth in size and voltage in the past few years, these transformers have shown an excellent record.

Transient voltage surges have long been recognized as one of the chief sources of trouble, and during the past five years, the klydonograph has yielded much information on the magnitude and frequency of occurrence of these surges on transmission systems under service conditions. More recently, the cathode ray oscillograph has been perfected, making it possible to record accurately voltage—time relationships occurring in a small fraction of a second. By means of this instrument it has been possible to obtain actual photographs of surges.

The voltage surges occurring on transmission systems, and, of necessity, those with which we are concerned as affecting transformers, can be divided into three general classes according to their origin; namely, arcing grounds, switching surges, and electrostatic or lightning surges. It is the purpose of this paper to analyze various types of these surges, and afford a common basis of studying their effects, particularly on grounded neutral systems.

Relative Importance of Arcing Grounds, Switching Surges, and Lightning Surges. Arcing grounds are discharges to ground, usually from one phase or line of a transmission system. In case the neutral of the system is grounded, the maximum voltage developed would be approximately two and one-half times the normal voltage to neutral.[2] For an isolated neutral system, the maximum voltage may be as great as six times normal.

Reviewing literature[3] on the subject, we find the data obtained on a number of systems covering the whole operating range of transmission-line voltages indicate that approximately 50 per cent of switching operations cause no appreciable voltage surge. The maximum voltage recorded on any system was six times normal, and that was caused by deenergizing a line.

As a rule, switching surges do not cause flashover of the line insulation. They must of necessity be of short duration in order to obtain excessive values, and may rise to a maximum in the order of a few microseconds. On the other hand, lightning surges attain values of many times normal line voltages. In many of the cases recorded by the klydonograph, flashover of the line insulation is known to have occurred. By virtue of the fact that the line insulation was flashed over, the magnitude of the voltage is much greater than for arcing grounds or switching surges. In Fig. 1 is shown a comparison of the voltages to be expected from the several sources, together with the normal voltages of the system, the transformer test voltages, and the 60-cycle dry flashovers of normally insulated lines. From this it may be seen that surges produced by lightning are of most serious consequence, and for very short surges with lower values for surges of longer duration may be as great as 14 times normal.

Factors Limiting Lightning Surge Voltages. The principal factor limiting the voltage on a transmission line is the spark over of the line insulation. The flashover of a string of insulators depends both upon the magnitude and the shape of the impressed surge, and in the case of lightning surges, is always greater than the 60-cycle flashover voltage. We may assume that failure commences as the 60-cycle spark-over voltage is approached, and that spark-over is a function of time and the voltage above this value. The tail of the surge, as well as the front, affects spark-over, and the more abrupt each is, the higher the voltage necessary to produce arc-over.

From experimental data[4,5] for the flashover of line insulators, it is estimated that the maximum voltage

1. Engineer, Westinghouse Electric & Mfg. Co., Sharon, Pa.

2. For all references see Bibliography.

Presented at the Pacific Coast Convention of the A. I. E. E., Santa Monica, Calif., Sept. 3-6, 1929. Complete copies upon request.

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which could exist on a line as a result of a direct stroke would be in the neighborhood of 2.5 to 2.7 times the 60-cycle crest sparkover. The curve for the probable maximum voltage, curve G, Fig. 1, is based on this computation. Points of this curve agree approximately with the maximum voltages recorded by the klydonograph.

In this connection, reduced line insulation, ground wires, protective gaps, and lightning arresters should be mentioned. Each tends to limit the voltage on the system, particularly lightning arresters.

The second factor limiting the potential surges on apparatus is attenuation.[6] Where the voltage of the surge is very high, the attenuation is very great. To this property of traveling waves much protection to connected apparatus is due.

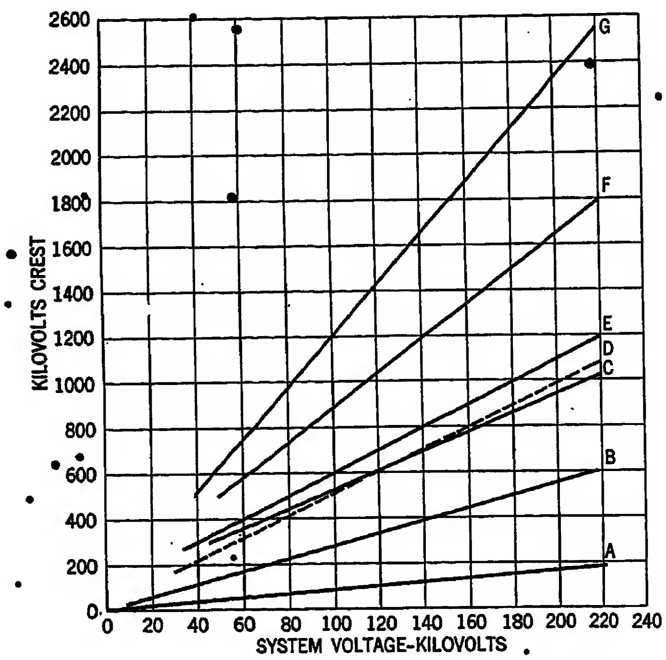

FIG. 1—COMPARISON OF SURGE VOLTAGES AND TRANSFORMER AND TRANSMISSION LINE INSULATION VOLTAGES (ESTIMATED)

A. Normal voltage of transformer (line to neutral)
B. Transformer test voltage
C. 60-cycle dry flashover of normally insulated transmission line
D. Probable maximum switching surges
E. Probable maximum voltage for 60-microsecond surge not causing flashover
F. Probable maximum voltage for 5-microsecond surge not causing flashover
G. Probable maximum lightning voltage possible (flashover on rise)

II. GENERAL CONSIDERATIONS

(A section of the unabridged paper is devoted to this matter)

III. EXPERIMENTAL RESULTS

The circuit used in conducting these tests is shown in Fig. 5. The capacitance C was charged from an alternating source by means of kenotron rectifiers and discharged through an inductance L and resistance R. The potential drop across the resistance was impressed upon the transformer terminal. A lumped impedance Zs, of approximately 500 ohms, was connected between the transformer terminal and the source of voltage supply. The terminals of the secondary winding were connected to ground through similar impedances.

Waves rising to a maximum in less than a microsecond and decaying to one-half value in 5 and 60 microseconds were considered representative of fairly short and long lightning surges and these, together with waves chopped while rising, were used principally in this

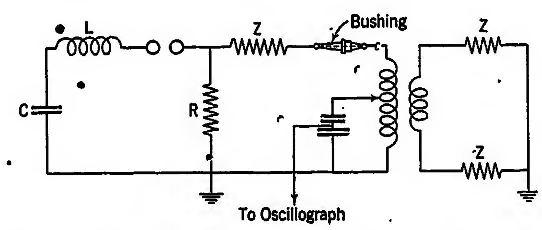

FIG. 5—SCHEMATIC DIAGRAM OF TESTING CIRCUIT

investigation. Waves of approximately 5- and 30-microsecond fronts were also used.

The effect of surges on the windings of the following transformers was studied in the course of this investigation:

3000-kv-a., 140,000- to 5000-volt single-phase, shell type transformer with the high-voltage winding divided into three groups.

667-kv-a., 66,000- to 7200-volt core type transformer with cylindrical low-voltage coils and circular pancake high-voltage coils. The winding was arranged on two legs with a reentry in the middle of each leg.

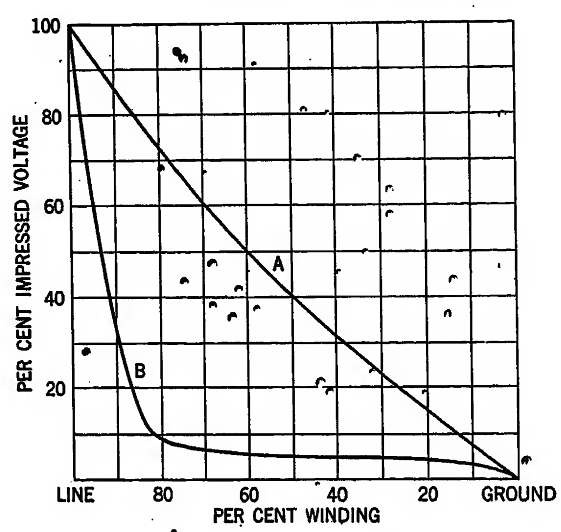

FIG. 7—COMPARISON OF VOLTAGE DISTRIBUTION IN LONG AND SHORT STACKS OF COILS

A. Short stack of wide coils
B. Long stack of narrow coils

The Effect of the Proportions of Winding on the Distribution of Voltage. Fig. 7 illustrates the difference in the voltage to ground in a short stack of wide coils and a long stack of narrow coils when subjected to a five-microsecond surge. These values represent approximately the initial voltage distribution and are

indicative of the worst stresses occurring in the stacks. Curve *A* represents what occurs in the line group of a well proportioned wide stack of coils and Curve *B* represents what occurs in a narrow stack of coils when short steep waves are impressed upon them.

When the windings are interleaved or broken up into

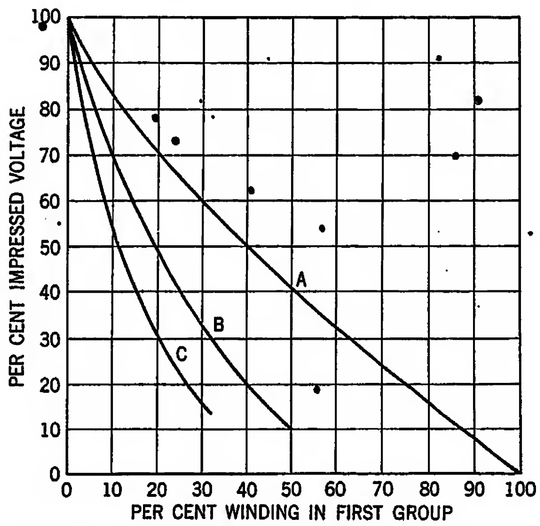

FIG. 8—THE EFFECT OF INTERLEAVED WINDINGS ON THE VOLTAGE DISTRIBUTION

A. Voltage distribution with one group
B. Voltage distribution with two groups
C. Voltage distribution with three groups

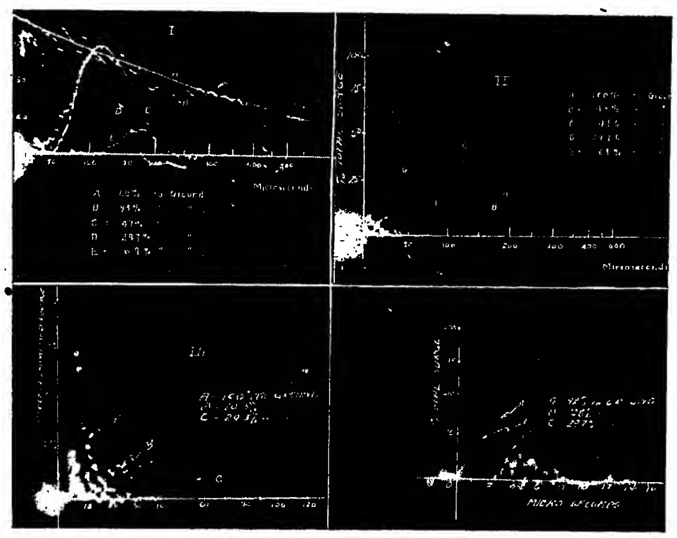

FIG. 9—OSCILLOGRAMS SHOWING VARIATION IN INTERNAL OSCILLATIONS OF 3000-KV-A. TRANSFORMER WITH DIFFERENT LENGTH SURGES

1. Very long surge, 250 microseconds to half value
2. Long surge, 60 microseconds to half value
3. Short surge, 5 microseconds to half value
4. Chopped surge

groups, the line group absorbs most of the surge voltage. Data were taken on the 3000-kv-a. transformer first by impressing a surge across the total winding; then across two groups, and finally across a single group of the winding. A five-microsecond surge was used and measurements of voltage were made to ground. Referring to Fig. 8, the three curves were seen to be of similar shape, or the distribution of voltage in the line group is practically unchanged by varying the number of groups. The discontinuous points in the curves indicate the division of voltage across the group.

Internal Oscillations and Voltage to Ground. When a steep-front surge strikes a transformer, oscillations are set up in the winding. The values attained by these oscillations depend largely upon the shape of the surge. Referring to the oscillograms, Fig. 9, the oscillations are seen to be higher for the longer tail waves. A point in the winding 29.7 per cent above ground reaches a maximum value of approximately 75 per cent of the total applied voltage for the extremely long wave,

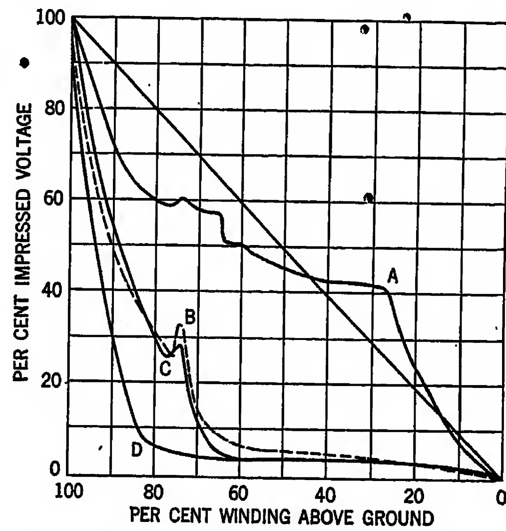

FIG. 11—MAXIMUM VOLTAGES TO GROUND FOR DIFFERENT TYPES OF SURGES

A. Voltage distribution in 3000-kv-a. transformer with 60-microsecond surge
B. Same with chopped surge
C. Same with five-microsecond surge
D. Voltage distribution in 667-kv-a. transformer with five-microsecond surge

approximately 47 per cent for the long or 60-microsecond wave, 10 per cent for the short or five-microsecond wave and 5 per cent for the chopped wave.

Thus it may be seen that if the surge is sufficiently short, the voltage by oscillation does not rise above the initial voltage acquired from the front of the wave. On the other hand, a measurement of the voltage above ground for longer waves would indicate the maximum values reached by oscillation. This is confirmed by the agreement between the curves (Fig. 11), and the oscillograms.

The natural frequency of the shell-type transformer investigated was approximately 5000 cycles and that of the core 6700 cycles. It is believed that the order of these fundamental frequencies is representative of that of power transformers in general.

Referring again to Fig. 11, a very close agreement between the voltage to ground for the five-microsecond and chopped waves is observed. This follows the explanation just given that the initial distribution and not the oscillatory portion of the transient was the factor determining the voltage to ground.

The breaks or departures from continuous smooth curves were caused by taps in the winding.

The voltage to ground for the 667-kv-a. transformer subjected to a five-microsecond surge is also given. A basis for comparing the two transformers is not simple. However, the curves show for the same surges that 86 per cent of the voltage drop occurs across 15 per cent of the winding of the 667-kv-a. transformer as against 57 per cent of the voltage for the same percentage of the 3000-kv-a. winding.

IV. Magnitude of Stresses in Transformers as Determined by the Line Conditions

Stresses within the Windings. Referring to Fig. 11, from which the stress along the length of the wind-

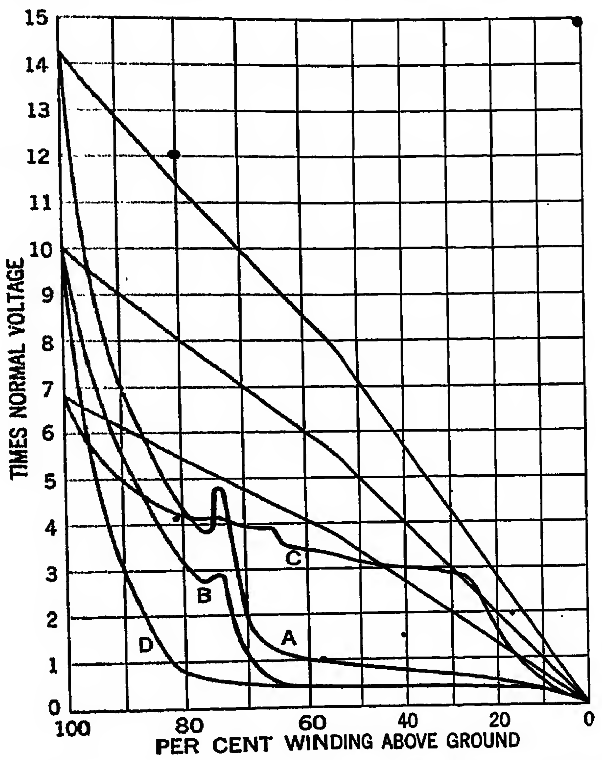

Fig. 14—Probable Magnitude of Internal Voltages above Ground

A. Chopped surge, 3000-kv-a. transformer
B. Five-microsecond surge, 3000-kv-a. transformer
C. 60-microsecond surge, 3000-kv-a. transformer
D. Five-microsecond surge, 667-kv-a. transformer

ing can be estimated, and to the probable maximum potentials on transmission line as given in Fig. 1, the following may be deduced:

The highest stresses are evidently those caused by surges with very steep fronts, as these give the worst initial distribution of voltage and attain the highest values which, in the case of surges limited by flashover of the line insulation may be of the order of 14 to 15 times normal. Surges of this character cause no fundamental oscillations on transformers having periods of the order of those investigated herein; therefore, the initial distribution is the only factor necessary to consider. This distribution is largely a function of the physical properties of the winding. By reference to the above curves it may be seen that the greatest stresses occur near the line end, where the winding is made of the simplest possible form of construction, free from taps, which lends itself for providing adequate insulation.

Stresses to Ground: The voltages to ground as expressed in the curves of Fig. 11 have been multiplied by the ratios of the probable maximum surge voltages of Fig. 1 and are plotted with respect to their relative values in Fig. 14. On this basis, the latter curves represent the maximum voltage stresses to ground obtained in the various parts of the transformer winding, either through internal oscillation or by the initial electrostatic induction. In recording these values, measurements by oscillograph and sphere-gap are in agreement within experimental accuracy. Obviously these stresses are placed upon the major insulation of transformers, and for uninterrupted service must be withstood. Since in this case, as in the previous case, the highest stresses are produced by the very short surges, the transformer major insulation may be subjected to 14 to 15 times normal voltage in the vicinity of the line end. In the mid-section of the transformer, the highest voltages are produced by the long surges and are three to five times normal. Their value is fixed by the amplitude of oscillation. The amplitude of oscillation is a function of the initial distribution which in turn is a function of the physical proportions of the winding. Transformers insulated sufficiently to withstand the maximum stresses at the line end should without difficulty withstand the stresses imposed at any internal portion, even though the insulation there is reduced.

The above conditions refer to the maximum surges expected in service. For longer surges such as represented by curves *E* and *F*, Fig. 1, or for surges removed a considerable distance from the transformer, the stresses would be diminished.

Acknowledgments

The author is pleased to acknowledge the valuable assistance rendered by Messrs. F. J. Vogel, J. F. Peters, J. M. Blackhall, and others of his associates, in the Engineering Department of the Westinghouse Electric and Manufacturing Company in obtaining the experimental data and preparing this paper.

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Abridgment of

Electrophysics

ANNUAL REPORT OF THE ELECTROPHYSICS COMMITTEE*

To the Board of Directors:

One of the Committee's principal functions has been to serve as a connecting organization between the world of physics and the Institute. We have been trying to serve this purpose by encouraging papers which bring in new concepts, phenomena, and terminology from working physicists, and discouraging contributions which are results of "inbreeding." Dielectric phenomena and dielectric theory are two particularly live topics, and there is a constant danger of unnecessarily burdening the Institute publications with contributions which contain more undigested data and unfounded speculations, and which do not bring us any nearer to a rational understanding of the underlying molecular phenomena.

Dielectrics

A large percentage of papers submitted to the Committee on Electrophysics has to do with dielectrics and their behavior. One of the sessions at the Winter Convention was devoted chiefly to this topic, and papers were presented on anomalous conduction, dielectric absorption, dielectric constant, power loss, and corona. Several other papers have been since approved for publication or for presentation at future meetings.

Much work on dielectrics is being done under the auspices of the Committee on Electrical Insulation of the National Research Council and also by the American Society for Testing Materials. Their reports and publications should be consulted in addition to the material found in the A. I. E. E. Transactions. There is also a Government Research Committee on this subject in England. Many valuable articles on dielectrics will be found in the *Archiv für Elektrotechnik,* and in some recent British and German books on different phases of dielectric behavior.

Under the auspices of the above mentioned Committee on Electrical Insulation, several subcommittees were formed in 1928, among others a Subcommittee on Physics, V. Karapetoff, Chairman, and a Subcommittee on Chemistry, F. M. Clark, Chairman. Both subcommittees are already functioning, and through them many prominent physicists and chemists have been drawn into the study of scientific aspects of dielectrics.

High-Voltage Research

Using the principle of charging capacitors in parallel and discharging them in series, very high impulse voltages have been generated for test purposes. A voltage of 5,000,000 has been produced in this way and even higher voltages have been applied to transmission lines. The phenomena of attenuation, reflection, etc., of traveling waves have been studied by means of the cathode ray oscillograph. This work is being continued on a larger scale. The cathode ray oscillograph was used also to record impulses on lines due to natural lightning. Only two records were obtained in this first attack on this problem, but a start has been made and more extensive data should be collected this summer. The cathode ray oscillograph was used for a laboratory study of a number of interesting and important phenomena, such as the impulse flashover of insulators and the distribution of transient voltages in transformers.

The year's work at the Ryan Laboratory, Stanford University, California, resulted in three papers. One, by Lissman[1] analyzes lightning phenomena in the light of laboratory experience, and gives a detailed picture of what actually goes on in a lightning stroke. The second paper by Carroll and Cozzens[2] reports results on sphere-gap sparkover voltages up to and over one million to ground. It was found that the voltage per inch required to break down gaps in excess of 9 ft. decreased so rapidly with increased spacing that it established an approximate economic limit of high voltage for power transmission. The final paper, by Dr. J. T. Lusignan[3] gives the probable history of an a-c. flashover, as obtained from oscillographic and spectroscopic evidence.

Dielectric Constant, Molecular Structure, and Molecular Moment

During the past year, considerable research has been carried out on the subject of molecular moment and its relation to dielectric constant and molecular structure. The work has centered chiefly around the Debye theory. In general, this theory is becoming more and more accepted, although a large number of the researchers find that the theory does not fit in with experimental behavior in a great many instances.

In a study of the variation of the dielectric constant of gases with temperature and pressure, Magdalene Forro finds in the *Zeitsch f. Physik,* 1928, 47, 430 that the constants of the Debye equation, $(\epsilon - 1)/(\epsilon + 2)$

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	K. B. McEachron,	

Liaison Representatives of American Physical Society
Dr. W. F. G. Swann, Prof. A. P. Wills.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

1. A. I. E. E. Trans., Vol. 48, Jan. 1929, p. 146.
2. A. I. E. E. Trans., Vol. 48, Jan. 1929, p. 1.
3. A. I. E. E. Trans., Vol. 48, Jan. 1929, p. 246.

$(T/d) = \alpha T + b$, change with temperature and pressure. For hydrogen, nitrogen and air, α (which is the optical contribution to the dielectric constant) is of constant value, while b (which is the permanent dipole contribution) is zero. For carbon monoxide the value of b varies with pressure at constant temperature. The temperature coefficient of b for carbon monoxide indicates a dipole moment of 0.108×10^{-18} at one atmosphere to 0.147×10^{-18} at six atmospheres of pressure. The variation of the permanent dipole contribution to the dielectric constant can be expressed as either a linear or as a quadratic function. For carbon dioxide, however, this permanent dipole effect varies with the density as a quadratic function, the dipole moment varying from 0.192×10^{-18} at one atmosphere to 0.217×10^{-18} at 6.53 atmospheres.

Study of the molecular moment and dielectric constant in organic and inorganic solutions has been a particularly favored field of investigation during 1928. In general, the work has been in agreement with the results obtained by G. Rock and S. Klosky published in the *Journal of Physical Chemistry*, 33, p. 143 (1929). They found that the dielectric constant of solver sols is essentially that of the dispersion medium.

Ferromagnetism

Heisenberg has been partially successful in explaining the origin of ferromagnetism on the basis of the spinning electron and the Fermi-Dirac statistical theory. His theoretical deduction is that a material cannot be ferromagnetic unless it is composed of atoms which have three-quantum electrons and which are symmetrically surrounded by at least eight neighbors.

Honda suggests that the electrons in the nucleus are responsible for the origin of ferromagnetism. His picture avoids the difficulty of the Larmor precession of extra-nuclear electron orbits.

Weiss and Forrer have redetermined the value of the Weiss magneton in iron and nickel, and reviewed the literature to show that the magneton is the unit in all magnetic materials.

The increase in specific heat, due to loss of magnetism near the magnetic transformation temperature, has been measured by Bates for manganese arsenide and compared with the values calculated according to Weiss from the magnetization-temperature curve, with good agreement.

Elmen has reported the remarkable magnetic properties which he has found in some alloys of iron, cobalt, and nickel. These alloys, called "perminvars," when properly heat treated, have permeabilities which are unusually constant up to fields of several gausses. They have therefore very small hysteresis losses for low flux densities.

Experimental Investigation of Thermal Relations of Energy of Magnetization

Walter B. Ellwood, graduate student at Columbia University, working on hysteresis in iron, has succeeded in his attempt to a solution of an outstanding problem in magnetism which has hitherto defied attack. The following note, which is a first report on this work was received from Professor A. P. Wills, under whose direction the investigation was carried on.

Experiments were undertaken for the purpose of determining the mechanism of the degradation of energy which accompanies magnetization in ferromagnetic substances. The experimental method consists in observing the change in temperature of a test specimen produced by a change in the magnetizing force at consecutive intervals in a single cycle of magnetization.

Propagation of Electromagnetic Waves in Space

The subject of wave propagation has been studied theoretically and experimentally and the existence of the Kennelly-Heaviside layer can be regarded as a fact. The resultant signal received at any point is the vector sum of the ground wave and the indirect wave coming down from the ionized layer. The waves radiated from a normal aerial have their electric vectors vertical to the surface of the ground, and almost so at the receiving end. This means in the optical language that the received ground wave is horizontally polarized. The downcoming wave is generally elliptically polarized and the resultant field of both waves is usually complex. This gives rise to bearing errors in direction finding and causes the well-known fading.

Hollingworth finds that downcoming waves which are longer than 10,000 meters are usually plane polarized. The direction of the plane is approximately constant during the day but during the sunset and sunrise periods it varies in a manner depending on the distance between the sender and the receiver. At some distances the plane is turned clockwise and at other distances, counter-clockwise.

For waves of 400 meters at distances of 100 miles the downcoming components are circularly polarized. This means that both the electric and magnetic vectors have constant amplitude but rotate synchronously, the direction of rotation depending on the direction of the earth's magnetic field. This would mean a right handed rotation in all parts of the Southern hemisphere.

For 15 and 50-meter waves, T. L. Eckersley finds the downcoming waves almost plane polarized, the plane rotating slowly with the period of a few seconds. This should produce fading when a vertical or a horizontal aerial is used for receiving. But fading seems mostly due to a change in intensity of the downcoming waves rather than to a change of phase with respect to the ground wave.

Physics of Radio Communication

In Europe, much attention has been given to the effect of trees, buildings, built up areas, etc., on the attenuation of radio waves. Examples of such studies are those of Barfield (*Inst. of Elec. Eng. Jl.*, 1928 and 1929).

Among the important investigations of short-wave

propagation are those of Heising (*I. R. E.* 17, 75, Jan., 1928), Taylor and Young (*I. R. E.* 16, 562, May, 1928), Mesny (*L'Onde Elec.* 7, 130, April, 1928) Meissner and Rothe (*I. R. E.* 17, 35, Jan., 1929) and others.

Our present knowledge of static is summarized in a paper by Watson Watt (E. W. and W. E. p. 619, Nov., 1928). Carson has shown that it is impossible to eliminate static disturbances in receivers by audio frequency balancing schemes (*I. R. E.* 16, p. 966, 1928).

Advances have been made in the production of oscillations having wavelengths of less than 1 meter. Important publications on this subejct are by Yagi (*I. R. E.* p. 715, June, 1928), Hollmann (*I. R. E.* p. 229, Feb. 1929), and Okabe (*Journ. Inst. of E. E. Japan,* March, 1928, p. 284).

An excellent summary of the status of direction finding was recently published in the *I. R. E. Proceedings* (March, 1929, p. 425) by Smith-Rose.

The Bureau of Standards has developed a successful aircraft radio beacon (*I. R. E.* 16, p. 890, July, 1928). An extensive bibliography on aircraft radio has been published by Joliffe and Zandoninini (*I. R. E.* 16, p. 985, July, 1928).

In the field of vacuum tubes, Hull[4] has developed a high-voltage two-element gaseous rectifier, and a three-element gas tube, both of remarkable characteristics. Four-element double grid commercial tubes have been developed, and five-element tubes are now in the experimental stage.

The most remarkable discovery that has been made recently in short-wave propagation is the discovery by Stormer and Hals of echo signals with time delays as great as 15 seconds after reception of the original signals (*Nature,* Vol. 122, Nov. 3, 1928, p. 681). Similar echoes have also been observed by van der Pol (*Nature,* Vol. 122, Dec. 8, 1928, p. 878). These Stormer-Hals echoes have aroused great interest, and several explanations have been advanced concerning their origin.

Subcommittee on Reactive Power

In October 1928 the A. I. E. E. published an English edition of the "Questionnaire on the Problem of Reactive Power," prepared by the National Roumanian Institute for the Study of the Development and Utilization of Sources of Energy, for the Advisory Committee for the Improvement of Power Factor of the International Conference on Large High-Voltage Systems.

This is a 21-page 9 by 12-in. pamphlet with an introduction by Doctor C. O. Mailloux. The questionnaire treats in great detail of the theoretical and practical aspects of the subject, with an extensive list of references appended.

The questionnaire has been referred by the Standards Committee of the Institute to the Committee on Electrophysics for an opinion. Since most of the members of this committee are following entirely different lines of work, it was deemed advisable to form a special subcommittee. Dean O. J. Ferguson of the University of Nebraska kindly consented to serve as chairman of the subcommittee.

Some Active Topics in Physics

One of the purposes of the committee being to act as a connecting link between the Institute and the field of pure physics, the following list of topics will be of interest. It represents some of the subjects on which physicists are working and on which papers are being regularly presented and articles written by the leading investigators. It will be noticed in particular that the old division into mechanics, heat, light, electricity, and sound, has been more or less obliterated, the electron theory and the quantum mechanics being the dominant foundation of most of the researches, except in acoustics.

Scattering of electrons by gases, liquids, and solids.

Diffraction of electrons by thin films and by crystals.

Absorption of electrons by vapors.

Effect of electrostatic and magnetic fields upon electrons, ions, and neutral molecules.

Spectra of various substances under different conditions, as bearing upon the nature of their atomic and molecular structure.

Energy distribution, attenuation, and absorption of radiation at different wavelengths.

Photoelectricity and photoelectric cells.

Effect of electric and magnetic fields upon spectra, and correlation of these effects with the atomic and molecular structure.

X-rays; their wavelength, electron levels, diffraction, fine structure, polarization, ejection of photoelectrons.

Characteristics of sparks and other discharges, including their spectra.

Thermionic emission and properties of triode valves.

Compton effect; Raman effect.

Behavior of electrons like waves and behavior of light quanta like particles; bridging the gap between matter, electricity, and energy.

Nature of light waves and of electrons.

Conduction in metals from the point of view of the new quantum mechanics.

Nature of magnetism.

Magnetic properties of crystals.

Experimental and theoretical study of atmospheric electricity and terrestrial magnetism, in terms of moving ions and of radiations.

Structure of the universe in terms of astronomical and spectroscopic evidence, assisted by Einstein's generalized theory of relativity.

New statistical mechanics, wave mechanics, quantum relations, indetermination principle, etc.

Quantum mechanics of chemical reactions.

Atomic structure and chemical valency.

Note. Attention is directed to Doctor M. I. Pupin's Editorial on *1928 Progress in Physics.*[5]

A General Trend in Physical Concepts

The present day period in physics may be said to have begun with the discovery of the electron in the closing years of the nineteenth century. This meant a new

4. A. I. E. E. Quarterly Trans., Vol. 47, July 1928, p. 753.

5. A. I. E. E. Journal, February 1929, Vol. 48, p. 92.

atomic concept of electricity. The introduction of the idea of quantum of energy, as the smallest amount of energy in a "chunk" of radiation of a given frequency, meant another new concept; namely, the atomicity of energy, at least in one of its forms. Einstein's relativity followed in 1905, and has brought in another new idea; namely, that a physical "law" may be different depending upon the size of the continuum to which it is applied and the magnitude of the velocities which come into play. In the Bohr-Sommerfeld theory of the atom (1913-1915), the three new concepts; namely those of electron, quantum, and relativity, were brought together in a masterly way to explain the observed complex structure of various spectra. Later, similar ideas were extended to molecular spectra and to the theory of specific heats, as being due to different forms of motion of the parts of a molecule relatively to one another.

Thus, an area of "picture theories" of the atomic structure was ushered in. Electrons were endowed with various forms of motion about a central nucleus to explain this or that phenomena; atoms were endowed with suitable forms of motion within a molecule to explain some other phenomena; and when a particular feature of a spectrum could not be accounted for, new motions were invented to explain it—for example, the spinning electron. In other cases, the observed spectra did not show all the lines predicted by the theory, and certain "principles" or "postulates" were introduced to exclude such lines *a priori* as not being in accord with one of these principles.

However, the picture-theory period was only short-lived, partly because the pictures themselves became unduly complex, especially for heavier atoms, partly because the theory proved to be inadequate on some essential points, and partly because in the very nature of the phenomena statistical results were desired, rather than an actual orbit of this or that electron in a particular atom. But a statistical problem, where billions of atoms are to be considered simultaneously, and where only the probability of a certain event is sought, rather than its certainty for a given atom, hardly lends itself to a picture. Just as an extreme advocacy of graphical methods on a branch of engineering usually leads to a reaction in favor of an analytical method, so the picture-theory period yielded its place almost overnight to a "mathematical-function" period in the midst of which we are now laboring.

Several brilliant European mathematical physicists, such as Heisenberg, Born, Jordan, Pauli, de Broglie, Dirac, Fermi, and Schrödinger, have developed various aspects of this new point of view, and while it would be entirely out of place to go into the details here, the following few remarks may indicate the general trend.[6]

Ideas are more general than objects or phenomena, and we are apt to come nearer the true interpretation of the universe by adhering as closely as possible to general ideas rather than by evolving specific pictures, especially if the latter have been borrowed from the big world of every day experience and transferred without change into the unknown intra-atomic world. But quantitative ideas are best expressed by mathematical formulas and operations, and so the problem is reduced to devising such formulas and operations and using them to describe and to predict phenomena, even though we may not be able to construct corresponding pictures within the atom. There is no contradiction in this because an individual atom is not yet susceptible to direct observation. The principal point to achieve is to make the mathematical theory agree with the observed phenomena in the minutest amounts of matter and energy with which an experimentalist deals.

As Haas correctly points out,[7] should the new point of view persist for any length of time, it cannot fail to affect our whole attitude towards physical laws and interpretation of nature. According to it, matter and radiant energy are both atomic, and do not differ radically from each other. Under certain circumstances, electrons behave like waves and waves behave like chunks of matter. Energy is converted into matter, and vice versa, and this process is going on in the universe continually, creating new worlds and destroying the old. A physical law does not dominate an event but merely establishes probabilities for this or that percentage, just as a statistical law does not affect births or deaths in a species of living beings. In the big visual world we may speak of an instantaneous position of a material point and at the same time of its instantaneous velocity. In the sub-atomic world, according to Heisenberg's principle of indeterminateness, such a statement would be absurd. If the coordinates of an electron are given we can only ask about the probability of a certain velocity, and vice versa. In the big world of interstellar spaces, other laws reign supreme; Euclidean geometry and ordinary mechanics hold no more, and what we observe in our every day life (or even in our best equipped laboratories) is but a very narrow aspect of the real laws of nature. We do not see the bigger relativity aspects of the fundamental laws of nature, because our distances are too small and our velocities too low. We do not see the fine-structure aspects of the same laws because of the crudity of our apparatus which permits our observing the microcosm only statistically.

The new attitude is one of humility, and if it is an attempt to free the laws of nature from an anthropocentric point of view, future generations will welcome it as a step in the right direction.

6. A symposium on Quantum Mechanics was held under the joint auspices of the American Physical Society and American Mathematical Society in New York City on December 31, 1928. Most of the papers and discussions may be found in the April 1929 issue of the *Franklin Institute Journal*.

7. Arthur Haas, "Materiewellen und Quanenmechanik," *Akademische Verlags-gesellschaft*, 1929, Chapter 19. See also V. Karapetoff, "Picture Theories Inadequate," an article to be published in the *Electrical World* during 1929.

The Sixty-Cycle Flashover of Long Suspension Insulator Strings

BY R. H. ANGUS*

Student Member, A. I. E. E.

Synopsis.—This is a study of the 60-cycle flashover of strings up to voltages of 1100 kv., undertaken at the Ryan High-Voltage Laboratory, Stanford University. Investigation was made of the variations in flashover voltage for similar horizontal and vertical strings, with and without shields and tower members. An attempt has been made to correlate these flashover voltages with the point-to-point and point-to-grounded-plane arc-over voltages established in 1928 at the Laboratory. [1]

INTRODUCTION

THE dry 60-cycle flashover voltage of long strings of cap-and-pin porcelain insulators, is of some importance in the design and selection of the insulation for any particular project. There are authorities who advocate the adoption of a wet flashover as the criterion;[2] but the difficulties which have been encountered in the standardization of a suitable "rain" or "mist" make it inadvisable to accept this as the only test of insulator strings.[3] Further, if Dr. L. B. Loeb's[4] theory of breakdown is established, it may be that power frequency arc-over voltages will be a measure of impulse voltage flashover of insulator strings, provided arcing-rings are designed and fitted to prevent cascading arcs.[5]

In all the publications dealing with the flashover of insulator strings, which the writer has seen, no reference was found to tests on strings in a horizontal position. Judging by the large numbers of strain strings in any high-voltage line, this would appear to be an important omission, which may be filled by the tests on horizontal strings to be described in this paper. Only one article mentioned flashovers of more than 750 kv.[6] Because deviations from a straight line flashover-distance relation only begin to appear above 600 kv., the experimental work was continued up to flashovers of 1100 kv., which is the maximum voltage to ground available at the Ryan High-Voltage Laboratory.

Doubt has been expressed as to the necessity of increasing the number of insulators in strain strings, by one or two, over the number in a normal suspension string. This seems to be standard practise to attempt to overcome the deterioration of insulation due to the accumulation of dirt and the heating effects of sunlight. But the flashover of similar clean strings in the two positions was not thought to be different,[2] although the form of the electrostatic field about vertical and horizontal strings cannot be the same.

THE NATURE OF FLASHOVER

The flashover of an insulator string is the breakdown of the surrounding air, and consequently follows the laws of conduction of electricity through gases, which have been formulated by Paschen, J. J. Thomson, J. S. Townsend, L. B. Loeb, F. W. Peek, and others. The process of breakdown is thought to consist of ionization of the air and disturbance of the electronic orbits, consequent on the applied voltage gradient, till the air attains a conducting or chemically reactive state. When this occurs a sharp spark takes place, the spark having many of the characteristics of a condenser discharge. The power arc immediately follows. In the preparation for breakdown, ionization is dependent on voltage gradient and therefore on the form of the electrostatic field. Previous to power-frequency point-gap arc-overs of above 500 kv., long "streamers" sparks reach out from the electrodes. The air in the paths of these sparks is conducting and their presence must influence the distribution of the field. It is conceivable that their influence is the main cause of the widely varying arc-over values which are observed.[7]

The field about an insulator string is, as is well known, by no means uniform. The equal capacities of the units, as they are in series, give a higher stress at the line end of the string than at any other place. Equalizing shields do much to unify the distribution of stress along a string, but they and grounded tower structures complicate the form of the field, so that the effect of their presence on the flashover of a string can hardly be accurately anticipated for any particular case. All that can be done is to discover the variations in flashover values due to surrounding objects, for some extreme cases.

THE TEST INSULATORS

Only two types of insulators were used in the tests. Both were standard ball-and-socket cap-and-pin porcelain insulators, whose principal dimensions are; insulator "A", diameter 10 in., pitch 5.75 in.; insulator "B" diameter 10 in., pitch 5.0 in.

It is hoped that the selection of this type of insulator will in no way prejudice the possibilities of other types, including that evolved by Dr. H. B. Smith.[8] Only ring shields at the line end and arcing-rings at the ground end of the strings were used, as arcing horns appear unsatisfactory.[5] The shields were to attempt

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1. For reference see Bibliography.

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29-134

to equalize the electrostatic stress on individual units, and the arcing rings were to insure that the arc clears the string at the ground end. The dimensions are below.

Shields. Single String; a circular torus, internal diameter 22 in. of 2.5-in. circular metal material, mounted from the line clamp so that the central plane of the torus was one inch below the top of the cap of the line unit. The whole shield was in metallic contact with the high-voltage line.

Double String; an oval ring, internal diameters 33 and 20 in., of oval material 1 in. by 0.5 in., mounted in a similar way to the single string shield with the 33-in. diameter in the plane containing the axes of the two strings. The 1-in. diameter of the material was parallel to the axes of the strings.

Arcing-rings. Single String; circular ring, internal diameter 20 in. of 1-in. by 0.25-in. flat material, mounted in metallic connection to ground, the 1-in. dimension parallel to the axis of the string. The ring was level with the porcelain of the ground unit.

Double String; similar in every way to the double string shield.

Flashover voltages of vertical and horizontal strings of both types of insulators, were measured for the following cases:

1. Strings without shields or arcing-rings.
2. Strings fitted with shields and arcing-rings.
3. Strings fitted with shields and arcing-rings, tower structures being present at the ground end of the string.

In each case the nearest object, other than these mentioned above together, with the high-voltage and ground cables was over 18 ft. from the string.

METHOD OF CONDUCTING TESTS

As the flashover of any gap is dependent on ionization, the maximum voltage reached before spark-over is the value that must be measured. With an alternating voltage, the required value is that of the crest immediately previous to spark-over. Thus, a satisfactory method of measuring this value must be devised; either the crest value or the wave form must be known, and the use of an oscillograph is obviously desirable. The technique of voltage measurement by means of an oscillographic record of the current through a water resistor, as developed in 1928 at the Ryan High-Voltage Laboratory,[1] proved to be invaluable. This method was used to calibrate the voltmeter coil of the high-voltage transformers, for each type of set-up. as differing capacities to ground and differing corona loads affect the constancy of the voltmeter coil's transformation ratio.

Five separate oscillograph measurements were made for each of a number of typical set-ups. The results so obtained were compared with voltmeter coil readings of other flashovers of the same strings. This led to a calibration curve for each type of string, so that voltmeter coil readings could be used for similar strings of different lengths.

Results were thus achieved more quickly than if an oscillograph had been used for every measurement.

No temperature or pressure connections of flashover voltages were made, as at no time during the tests were the conditions sufficiently far from the standard of 760 mm. and 25 deg. cent. to warrant such connections.

COMPARISON OF FLASHOVER VOLTAGES

There are certain principles which must be accepted before flashover values of different strings may be compared; these are:

1. Flashover values should be referred to the arc-over distance and not to the number of units in the string. The arc-over distance is the length of the shortest path in air which arc can take from the line to the ground end of the string.
2. Comparison of the flashovers of complete strings

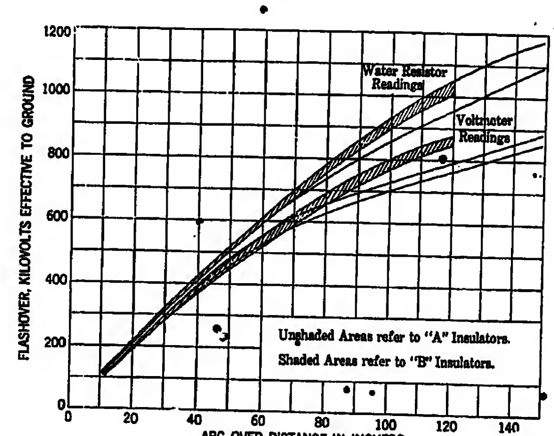

FIG. 1—FLASHOVER OF SUSPENSION INSULATORS, STRAIN POSITION, UNSHIELDED

under working conditions should be made only with each other, or some standard, and not with the flashover value of one unit of the string.[9]

3. The lowest observed flashover is the important value. Proceeding on these lines, an attempt has been made to relate the lowest flashovers of suspension and strain strings with the standards of the point-to-point and point-to-grounded-plane arc-overs.

DISCUSSION OF RESULTS

As the flashover of a string of insulators to a certain extent is dependent upon the initial state of ionization of the surrounding air, a constant flashover voltage cannot be expected, and the values may be represented rather by an area than by a line curve. This is done in Fig. 1. The areas denote the range within which the flashover of a strain string may occur, for the two types of insulators which were tested. A comparison is also made between the values derived by the water resistor method and the direct voltmeter readings. This shows the necessity for calibration of any particular arrangement of apparatus.

With "B" insulators, the calibration ratio increases steadily with the string length, which is a result of the increasing corona load as the flashover voltages grow larger. With "A" insulators a greater change in the ratio sets in at 550 kv. This is due, first, to the increasing corona, and second, to priming which occurs with more than six of this type of unit. "Priming" is a term applied to the short, snapping sparks over the

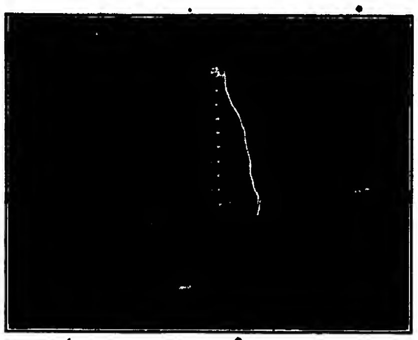

FIG. 2—NON-CASCADING FLASHOVER OF VERTICAL STRING OF 10 "A" INSULATORS

line units, occurring before arc-over. It is the direct translation of the French expression for this phenomenon,[9] and should, in the opinion of the writer, be used in preference to "cascading," which should de-

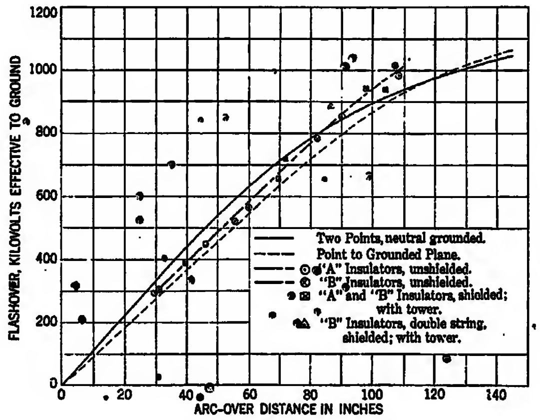

FIG. 3—FLASHOVER OF SUSPENSION INSULATORS, VERTICAL POSITION, LOWEST OBSERVED VALUES

scribe only the type of arc that clings close to the porcelain in its passage from one cap to the next.

LOWEST OBSERVED VALUES

1. *Strings in the Vertical Position.*

(a). "A" and "B" insulators, unshielded.

In this position, the conductor has a very considerable shielding effect on the string; so much so that no priming took place, and only 108 in. could be arced over with the 1100 kv. available. There was some cascading with "A" insulator strings of above ten units. Fig. 2 is a typical non-cascading arc-over.

(b). "A" and "B" insulators, with shields, arcing-rings, and tower members.

The lowest flashover voltages for the same arc-over distances are very similar to those for unshielded strings; the effect of the conductor is nearly as much as that of the shields in equalizing the stresses on individual units and preventing both priming and cascading. This is specially noticeable with the smaller pitched "B" insulators.

The values for shielded and unshielded strings are so equal that one curve serves for both sets. (Fig. 3.) The curve is approximately midway between the point-to-point and point-to-plane curves; the deviation from this position at above 750 kv. is due to the effect of the capacity-to-ground on a vertical gap, which causes about 20 per cent increase in the arc-over value of a 110-in. point-gap when the lower point is moved from ground level to 15 ft. above it.[1]

In order to discover any effect of the vertical part of

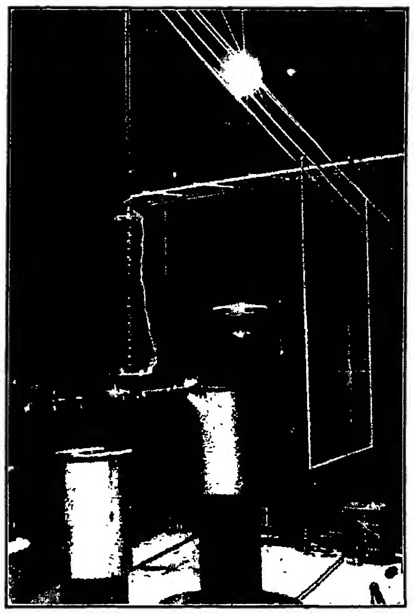

FIG. 4—FLASHOVER OF 20 "B" INSULATORS, WITH SHIELDS AND TOWER MEMBERS IN POSITION

towers on flashover values, a large wire screen was erected 10 ft. 10 in. from the nearest point of the shield of a string of 20 "B" insulators, and the screen was connected to ground. (Fig. 4.) Voltmeter readings of flashovers were taken with and without the screen in place. The averages of the two sets of readings were equal, showing that the voltmeter coil calibrations of the two set-ups were the same. But the lowest observed values were 900 kv. with the screen and 930 kv. without. It is probably safe to infer that the exploring streamer sparks were influenced by the presence of the screen, resulting in a 3 per cent lower flashover. This is barely greater than the limits of experimental error. Consequently it may be said that the important part of the tower, as regards flashovers, is the member at the ground end of the insulators.

The flashover voltage of a double string when

shielded, is sufficiently near to that of a similar single string to assume that they are equal, provided they have equal arc-over distances, (Fig. 3).

2. *Strings in the Horizontal Position.*

In the horizontal position the conductor provides no shielding effect. In actual transmission lines, the jumper at anchor towers would give some shielding; but it was decided to use an extreme case, as might be found at a terminal point, where the lead to the transformers or switchgear is in such a position as to shield the insulators but little.

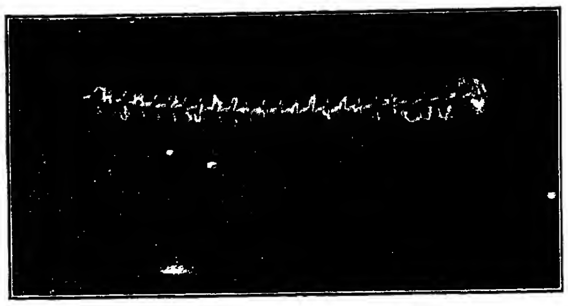

FIG. 5—FLASHOVER OF 25 "A" INSULATORS, STRAIN POSITION

(a) "A" insulators, unshielded.

The lowest flashover voltages of unshielded strings of "A" insulators are mid-way between the point-to-point and point-to-plane values, up to about 750 kv. Above this, both priming and cascading (Fig. 5) become very marked, and the curve runs below those of the two standards. (Fig. 6.) It should be noted that 25 "A" units were arced over only because priming and cascading occurred. The flashover of 25 of the closer pitched "B" units was beyond limits of the high-voltage transformers, for with them there was less priming and cascading. (Fig. 7.)

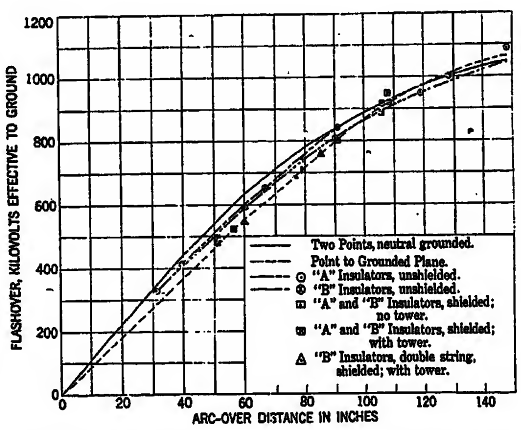

FIG. 6—FLASHOVER OF SUSPENSION INSULATORS, STRAIN POSITION, LOWEST OBSERVED VALUES

Fig. 8 is interesting, as it visibly demonstrates the need of shields and arcing-rings; corona from the high-voltage lead has shielded the first nine units, but cascading has occurred on the ground unit.

(b) "B" insulators, unshielded.

The smaller amount of priming with "B" insulators results in a higher flashover for a given arc-over distance than with the "A" insulators, although there is hardly any difference between the flashovers of the two types for strings of less than 15 units.

(c) "A" and "B" insulators, with shields, arcing-rings, and tower members.

Fig. 9 shows a typical arc-over. An arc to the tower sometimes occurred, and the flashover was frequently below the string but in every case the arc cleared the units.

The flashover voltages were the lowest of all those measured. They agree very closely with the point-to-grounded-plane values, as might have been anticipated from the position of the high-voltage lead with respect to the grounded tower.

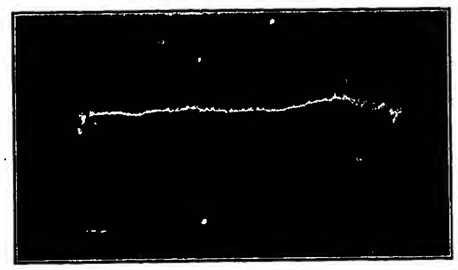

FIG. 7—FLASHOVER OF 22 "B" INSULATORS, STRAIN POSITION

FIG. 8—FLASHOVER OF 10 "A" INSULATORS, STRAIN POSITION

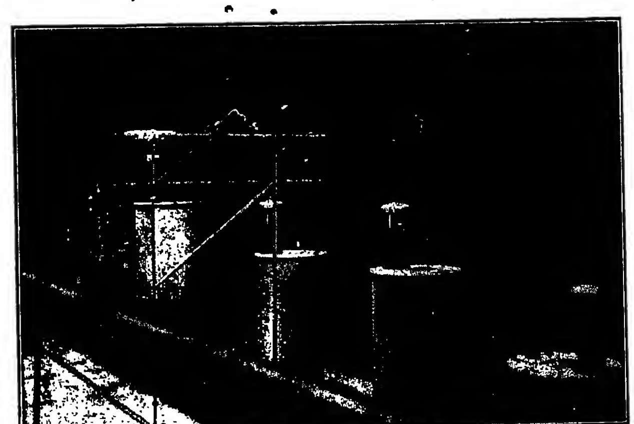

FIG. 9—FLASHOVER OF 20 "A" INSULATORS, WITH SHIELDS AND TOWER MEMBERS IN POSITION. WATER COLUMN RESISTOR IN FOREGROUND

CONCLUSIONS

1. *Variation in Pitch.* With strings in any position which are shielded (either by the conductor or by

shields) a 15 per cent variation in pitch does not affect the arc-over.

With strings which are not shielded cascading and priming may result on an increase in pitch. This will lower the flashover value.

The 5-in. pitch of the "B" insulators seems to be as large as a 10-in. diameter unit will stand without cascading. This is in close agreement with the results of G. Viel[9] for cap-and-pin insulators 11.4 in. in diameter and 5.9 in. pitch. In other words, for unshielded strings the pitch should not be more than about half the diameter of the unit.

2. *Shielding.* All strings (except perhaps those below 15 in. long) should be shielded. With vertical strings the conductor may provide sufficient shielding if the pitch and therefore the variation in stress on individual units, is not too great; though to be certain that the flashovers clear the string, arcing-rings should be used.[5] In other positions the conductor may not provide sufficient shielding, then ring shields must be fitted.

3. *The Flashover Voltage-Distance Relation* is not straight line, but lies between the point-to-point and point-to-ground-plane curves.

4. *The Lowest Flashovers* are obtained with strain strings. But these values are not below the point-to-grounded-plane arc-overs for the same distances.

5. *Length of Strain Strings.* These need not be more than five per cent longer than suspension strings; that is, one unit in twenty should be added to the normal vertical string to guard against the capacity effect of the strain towers. Additional units may also be necessary to overcome special local atmospheric or dirt conditions.

6. *Double Strings* have the same flashover as single strings of the same length, if both are adequately shielded.

7. *Calibration of Voltmeter.* Voltmeter-coil (or potential-transformer) readings should be calibrated by some suitable method for each particular type of set-up.

ACKNOWLEDGMENTS

The author is deeply indebted to Dr. H. J. Ryan for his helpful criticisms and to Professor J. S. Carroll and the other members of the Laboratory staff whose experience and assistance, both mental and physical, were invaluable.

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A 4000-LB. TELESCOPE DISK

The most serious difficulties met in producing large pieces of glass include properly melting the amount of glass required, transferring it to a mold to produce the desired shape while maintaining the necessary quality, and finally, cooling it at such a rate that it does not crack and is free from disturbing internal stresses.

Because of the lack of definite information on methods of making satisfactory pieces of glass which could be used for large telescope reflectors, the Bureau of Standards undertook to produce a 70-in. disk.

It was first necessary to make pots sufficiently large to hold the amount of glass required. The pots were "cast" in a plaster of Paris mold by a method developed at the Bureau. A hole was provided near the base of the pot which could be plugged during the melting of the glass and through which the glass could be tapped.

The combined mold and annealing furnace into which the glass was tapped consisted of four essential parts: the metal forms, the lining, the heating elements, and the insulation.

The temperatures of the melting furnace and of the annealing furnace were controlled electrically. The pot was burned very slowly, 30 days being required to reach a temperature of 1425 deg. cent., at which the glass would be melted.

When all arrangements were completed for tapping the pot, the water-cooled plug was removed and the molten glass began to flow. When practically all the glass was in the mold, the lid was put in place. The glass was cooled to 600 deg. cent. as rapidly as the furnace structure would permit. During the next two months the heating current was gradually reduced until the temperature for annealing was reached. The glass was annealed for 41 days at 461 deg. cent.

Four and a half months after the cooling from annealing temperature started, the furnace and its contents were practically at room temperature. The glass was found to be in satisfactory condition.

The disk was 69.75 in. in diameter, 11 in. thick, and weighed approximately 4000 lb. The maximum strain detected was well within the limit permissible for optical instruments of the highest precision.

ILLUMINATION ITEMS

Submitted by
The Committee on Production and Application of Light

TWENTY-AMPERE SERIES CIRCUITS FOR STREET LIGHTING

C. J. Stahl[1]

Wherever lamps are to be installed on a fairly close spacing, there is a growing tendency to use 20-ampere straight series street lighting circuits in preference to 6.6-ampere circuits, which have been so generally used in the past. Several 20-ampere systems have been in use for more than a year, and reports of operation are very favorable.

Those who advocate the use of 20-ampere circuits maintain that the 6.6-ampere practise is a heritage of the days when arc lamps were in general use for street lighting service. It is pointed out that on underground circuits, either No. 6 or No. 8 copper conductors are used, and that these have a current-carrying capacity considerably in excess of 6.6 amperes. When this current-carrying capacity is not properly utilized, a share of the copper investment is going to waste. Furthermore, insulation costs are unnecessarily increased, since at the lower current rating for a given load, the total circuit voltage is higher than for the 20-ampere circuit. On the 20-ampere straight series circuits the use of individual auto-transformers or series transformers at the lamps is unnecessary. This somewhat improves the efficiency and power factor and naturally the investment cost is less, due to the omission of these items.

There appears to be no element of the equipment, installation or maintenance carrying a higher cost for the 20-ampere circuit than for the 6.6-ampere circuits but there are several items in which the cost is considerably reduced.

For a given circuit load it is obvious that the total circuit voltage is reduced approximately 66 per cent. In this case the cost of underground cables is substantially less. On the other hand, for a given cable voltage rating, it is possible to supply approximately three times as many units on a single circuit when operated at 20 amperes.

The use of 20 amperes, however, does make necessary the omission of steel tapes from underground cables. During the past two or three years, this has brought about the development of the so-called "non-inductive" cables, in which the steel tapes have been entirely omitted or replaced by non-magnetic fibrous material. In duct systems, in which the ducts are of non-magnetic material, naturally no difficulties are experienced from the standpoint of excessive reactance losses.

The advantages of the 20-ampere system seem to apply either to ornamental or overhead types of street lighting, providing that the spacing between the units does not much exceed 150 ft. In the case of abnormally long spacings the conductor losses reach the point of balance as against the savings in other factors.

1. Westinghouse Electric & Manufacturing Co., South Bend, Ind.

CALORIMETER TEST ON 68,750-KV-A. TURBINE GENERATOR

J. M. Calvert[1]

Although a number of calorimeter tests have been made in this country and abroad to determine the loss in turbine generators when operating at the full-load full-voltage 0 per cent power over exciter condition, very little if anything has been published on tests at 80 per cent power factor, and the idea has always lurked in the minds of engineers that possibly the load loss under these conditions might be of a different magnitude.

Recently two duplicate 68,750-kv-a. turbine generators were coupled electrically and mechanically, and the losses of the machine which was operating at 80 per cent power factor as an over-excited generator were measured by the calorimeter method; that is, the kilowatts to the air stream, which comprised about 98 per cent of the total loss occurring within the frame, were computed from measurements of the volume and temperature rise of the air passing through the machine. The remaining loss was estimated from temperature measurements at various points on the frame and the air velocities over the outside surface.

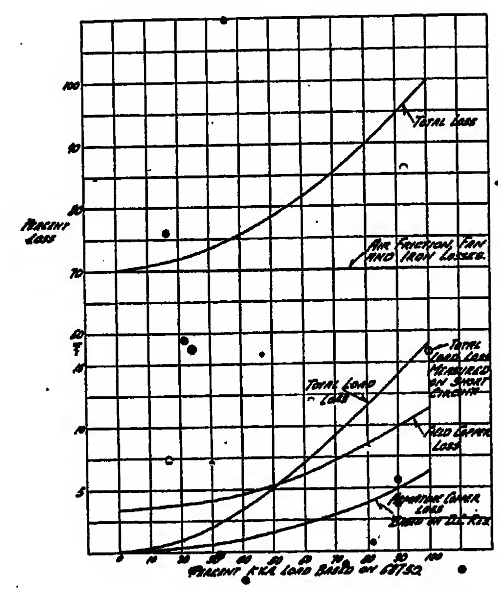

Fig. 1

The data obtained showed that the full value of load loss as measured on short circuit was practically equal to the load loss at the full-load full-voltage 80 per cent power-factor condition as determined by the calorimeter tests. This test furnishes a verification of the present A. I. E. E. standard method of measuring stray-load loss for commercial guarantees.

1. Westinghouse E. & M. Co.

INSTITUTE AND RELATED ACTIVITIES

The District Meeting in Chicago

Some of the most vital of recent developments in electrical engineering will be discussed at the District Meeting of the Institute which will be held December 2 to 4 at the Drake Hotel, Chicago, Ill. Inspection trips of special interest have been arranged and a banquet and dance will be enjoyed.

Two Student Sessions form another important part of the program. The schedule of all events is as follows:

PROGRAM OF CHICAGO MEETING

(All sessions will be held in the Ballroom)

MONDAY, DECEMBER 2

9:00 a. m. Registration.

9:30 a. m. **Session on Student Branch Activities.**

J. H. Kuhlmann, presiding.

A series of reports by Branch chairmen will be presented. A prize of $10.00 will be awarded for the best report.

2:00 p. m. Formal Opening of Meeting by President H. B. Smith.

Address of Welcome by Chicago Association of Commerce.

Session on Communication.

W. O. Kurtz, presiding.

Recent Developments in Telephone Toll Service, by W. H. Harrison, American Telephone & Telegraph Co.

The Chicago Long Distance Toll Board, by E. O. Neubauer and G. A. Rutgers, Illinois Bell Telephone Co.

Manufacture of Telephone Carrier and Repeater Apparatus, by R. C. Glasier, Western Electric Co.

Air Transport Communication, by E. L. Jones and F. M. Ryan, Bell Telephone Laboratories.

TUESDAY, DECEMBER 3

9:30 a. m. **Session on Power Plants.**

F. H. Lane, presiding.

The Future of Higher Steam Pressures, by I. E. Moultrop, Edison Electric Illuminating Company of Boston.

Use and Design of Fault Ground Bus, by R. M. Stanley and F. C. Hornibrook, Byllesby Engg. and Mgt. Corp.

Increased Voltages for Synchronous Machines, by C. M. Laffoon, Westinghouse Elec. & Mfg. Co.

Double Windings for Turbine Alternators, by P. L. Alger, E. H. Freiburghouse and D. D. Chase, General Electric Co.

A 40,000-kw. Variable-Ratio Frequency Converter Installation, by E. S. Bundy, Niagara Lockport and Ontario Power Co. and A. Van Niekirk and W. H. Rodgers, Westinghouse Elec. & Mfg. Company.

2:00 p. m. **Student Technical Session.**

J. H. Kuhlmann, presiding.

Relation Between the Branches and the Institute, by H. H. Henline, Assistant National Secretary, A. I. E. E.

What I Expect to Find When I Get Into Industry, by H. W. Hasse, Marquette University.

Personnel Selection in Public Utilities, by A. O. Alstadt, Marquette University.

Electric Power Transmission in Iowa, by E. M. Ellingson, The State University of Iowa.

Experiences with Single-Phase Condenser Motors, by S. E. Burgduff, Marquette University.

Headlight Testing, by J. C. Newhouse, University of Minnesota.

Testing of Reduction Gear Units, by G. P. Maurer, Marquette University.

Determination of the Temperature of Underground Power Cables from Load, by J. E. Dean, Michigan State College.

Cooperative Engineering, by R. J. Abele and F. J. O'Keefe, University of Detroit.

A Discussion of the Recent Public Utility Investigation at Washington, by E. G. Conroy, University of Notre Dame.

3:30 p. m. **Board of Directors' Meeting (Room D).**

6:45 p. m. **Banquet and Dance (Ballroom).**

WEDNESDAY, DECEMBER 4

9:30 a. m. **Session on Transmission and Distribution.**

H. W. Eales, presiding.

Theory of a New Valve Type Lightning Arrester, by J. Slepian, R. Tanberg and C. E. Krause, Westinghouse Elec. and Mfg. Company.

Low-Voltage A-C. Networks, by R. M. Stanley and C. T. Sinclair, Byllesby Engg. and Mgt. Corp.

An Economic Study of an Electrical Distributing Station, by W. G. Kelley, Commonwealth Edison Co.

Experience with Carrier-Current Communication on a High-Tension Interconnected Transmission System, by Philip Sporn and R. H. Wolford, American Gas & Electric Co.

Automatic Regulation for Synchronous Condensers Equipped with Super-speed Excitation, by L. W. Thompson and P. J. Walton, General Electric Co.

2:00 p. m. **Session on Research and Development.**

A. H. Lovell, presiding.

Polyphase Induction Motors, W. J. Branson, Robbins & Myers, Inc.

Recording Torque Indicator, by G. R. Anderson, Fairbanks, Morse & Co.

Effect of Armature Resistance on Stability of Synchronous Machines, by C. A. Nickle and C. A. Pierce, General Electric Co.

Ionization Currents and the Breakdown of Insulation, by J. J. Torok and F. D. Fielder, Westinghouse Elec. & Mfg. Co.

Heat Radiation in Inter-Reflection Cases, by A. D. Moore, University of Michigan.

INSPECTION TRIPS

There will be quite a number of attractive inspection trips, including those to the New State Line Generating Station, Crawford Avenue Generating Station, a typical electrified steel mill, a high-capacity transmission substation, the Western Electric factory, an automatic telephone exchange, and several others.

Members should register as soon as possible for trips they wish to take. Complete information will be available at the registration desk at the opening of the meeting.

Ladies' Entertainment

The Ladies' Entertainment Committee is planning a very interesting program, including trips to the Art Institute, the Live Stock Show, and the Field Museum—also a bridge party and tea. A shopping service will also be available.

Reduced Railroad Rates

Railroad tickets from certain territories to Chicago may be purchased at reduced rates, available to anyone who visits Chicago during the International Live Stock Show, which will be in progress at the time of the meeting. The round trip rate will be one and one-half times one way fare for those starting east of Chicago. It will be one and one-third times one way fare for those starting from west of Chicago. Local ticket agents should be consulted regarding territories, restrictions in dates, and other details.

Hotel Reservations

Reservations for hotel rooms should be made by application direct to the hotel. Rates for the headquarters hotel, the Drake, as well as for other hotels are given in the following tabulation. Reservations should be made early in view of the expected large attendance at the Live Stock Show.

Hotel	Room rates per day (minimum)	
	Without bath	With bath
Drake	——	$5.00 4.00*
Pearson	$3.50	
McCormick	3.00	
Knickerbocker	2.50	
Maryland	2.50	
Allerton	2.50	3.00
Eastgate	2.50	
Alexandria	1.50	2.00
Ontario	1.50	2.00

*Special rate for Students only.

Committees

The District Meeting Committee which is arranging the meeting is as follows: W. T. Ryan (Vice-President in District No. 5) *Chairman*; T. G. LeClair, *Vice-Chairman*; A. G. Dewars, *Secretary*; J. H. Kuhlmann, M. A. Faucett, Oscar Gaarden, L. F. Hickernell, P. B. Juhnke and F. H. Lane. The chairmen of the other committees are: *Technical Program*, F. H. Lane; *Hotel and Registration*, J. E. Kearns; *Finance*, K. A. Auty; *Trips and Transportation*, H. E. Wulfing; *Publicity*, F. R. Innes; *Entertainment and Banquet*, H. W. Eales; *Ladies*, Miss Helen Norris; and *Student Activities*, J. H. Kuhlmann.

En Route to World Engineering Congress

On October second the principal group of American and European engineers en route to Tokio to attend the World Engineering Congress left New York on a special train via the Baltimore and Ohio Railroad. About 80 were aboard the train and this number was considerably increased by accessions at various places in the taking on of the foreign engineers who had arrived in New York during August and September and who left earlier for the purpose of visiting places of engineering interest on their way to San Francisco.

When the train reached Washington, it was met by a well organized local committee, and the entire party was taken to the Mayflower Hotel, selected as headquarters.

Upon the evening of their arrival, His Excellency, Katsuji Debuchi, Japanese Ambassador to the United States, entertained more than 150 engineers in a most hospitable manner. Ambassador Debuchi, in a short appropriate address following the banquet, welcomed the delegates and their friends and wished them a happy journey. Elmer A. Sperry, Chairman of the American Delegation, responded to this address. The occasion was an exceedingly enjoyable one and afforded a much appreciated opportunity for American, European, and Japanese delegates in attendance to become better acquainted.

Upon completion of the sightseeing trip about Washington, (which included Mt. Vernon,—the home of the first engineer President,—the Bureau of Printing and Engraving, the Pan American Union, Museums, the Capitol, Library of Congress, Arlington National Memorial, the embassies, legations, and even the zoological gardens), the delegation called at the White House and paid its respects to President Hoover who was one of the early sponsors of this movement for a World Engineering Congress in Tokio. He shook hands warmly with each member of the delegation, wished them a pleasant journey, and stood for his photograph with the delegation.

The special train bearing the delegates away from Washington left at 3:55 p. m., on the third, scheduled to stop at Chicago, Los Angeles and San Francisco, and in each place the delegates were met by the local engineering societies; thence, on to Hawaii.

The train arrived in Chicago early October fourth and the acting local committee ably conducted the visitors upon the various excursions of interest; at noon the Western Society of Engineers entertained the entire group at luncheon.

Leaving Chicago late on the afternoon of October fourth, the special train stopped a whole day at the Grand Canyon, and another day at Pasadena and Los Angeles. The local committee of engineers provided enjoyable events at Los Angeles and San Francisco, the latter city being reached the morning of October ninth.

About 300 engineers and members of their families sailed October tenth from San Francisco on the *Korea Maru* of the Nippon Yusen Kaisha and the *President Jackson* of the Dollar Line. Some of those unable to obtain accommodations on these two ships were obliged to embark on steamers from Seattle and Vancouver.

After a stop of two days in Honolulu, the two steamers left, scheduled to reach Yokohama October 27th, the Congress to open on the 28th and to terminate on November 10th. After this, various excursions in Japan and elsewhere have been scheduled by the Japanese committees in charge of the arrangements for the Congress.

NATIONAL RESEARCH COUNCIL

THREE-DAY INSULATION CONFERENCE AT M. I. T.

The Committee on Electrical Insulation, Division of Engineering and Industrial Research, National Research Council, of which Doctor J. B. Whitehead is Chairman, will hold an Annual Meeting and three-day Conference at the Massachusetts Institute of Technology, November 14-16, inclusive. The first day will be devoted to meetings of the subcommittees. On Friday, November 15, the conference will be welcomed by Doctor Stratton, President of the Massachusetts Institute of Technology, and the conference will be opened by the address of Doctor J. B. Whitehead. Technical sessions will follow and there will be discussion of the research work now under way in the laboratories of the M. I. T. Saturday morning, the 16th, will be devoted to a technical session at which will be presented progress reports of research work in laboratories of the Universities of Illinois, Harvard, Johns Hopkins, and Massachusetts Institute of Technology. The conference will be the guests of M. I. T. at luncheon each day. Other social features are also being arranged.

Among those to present papers are Messrs. W. F. Davidson, Brooklyn Edison Co., C. F. Hirshfeld, Detroit Edison Company, D. W. Roper, Commonwealth Edison Co., R. W. Atkinson, General Cable Corporation; Professors E. B. Paine, University of

Illinois, C. L. Dawes, Harvard University, J. B. Whitehead, Johns Hopkins University, P. H. Moon, Massachusetts Institute of Technology, and others.

Annual Meeting of the American Mathematical Society

The American Mathematical Society, for its Annual Meeting December 27-28, 1929, to be held at Lehigh University, Bethlehem, Pa., is arranging that Friday be given to the presentation of the usual type of papers and that Saturday be devoted to a symposium on the mathematics of engineering. The general topic chosen for the Saturday sessions is *Differential equations of engineering*, and it is proposed tentatively that, both morning and afternoon, three half-hour papers be given by men eminent in their fields. This part of the program is being arranged because of a wish expressed by some members of each of the two groups—mathematicians and research engineers—for closer cooperation.

All interested are cordially invited to attend. Headquarters for the meeting will be at the Hotel Bethlehem, and further details are being planned by the Committee on Arrangements, Professor Tomlinson Fort of Lehigh University, Chairman. Printed program will be sent upon request to the Secretary, R. G. D. Richardson, 501 W. 116th Street, New York, (after December 7), who will gladly furnish other desired information.

The sessions will be held in the new Packard Laboratory for electrical and mechanical engineering.

Those participating in the program are H. W. March, Department of Mathematics, University of Wisconsin; Vannevar Bush, Department of Electrical Engineering, Massachusetts Institute of Technology; T. H. Gronwall, Department of Physics' Columbia University; A. Nadai, Research Laboratory, Westinghouse Electric and Manufacturing Company, (formerly of the University of Göttingen); R. H. Park, Engineering Department, General Electric Company; and S. Timoshenko, Department of Mathematics, University of Michigan, (formerly with the Westinghouse Electric and Manufacturing Company).

Massachusetts Institute Hears Hydraulic Engineer

Starting October 2, Doctor Dieter Thoma, Director of the Hydraulic Institute of the Technical University of Munich, Germany, gave a series of lectures at Massachusetts Institute of Technology, Cambridge, on the following subjects:

Development of the design of Kaplan Turbines and some recent installations, including Rybourg-Schworstadt Plan; cavitation in hydraulic turbines and pumps; methods of improving the shape of blades of turbines and centrifugal pumps; the hydraulic storage of energy; dissipation of energy in fluids; experimental determination of losses in pipe fittings and experiments with various devices; the hydroelectric plants of the Mittlere Isar A. G. and experimental researches for them; stability problems involved in governing hydraulic turbines; self-supporting pipes of large diameter with thin walls; effect of scale in model tests and general remarks about hydraulic laboratories for turbine research illustrated by moving and still pictures.

Doctor Thoma has consented to lecture before the Washington Society of Engineers on November 6, at which time he will deliver an illustrated lecture on the Kaplan turbine. By special request, he will also treat, in a limited time, the subject of cavitation.

The Washington Award

Members of the Institute are reminded that through Secretary F. L. Hutchinson, as representative, they may participate in the Washington Award.

This prize,—a bronze plaque,—is presented annually to an ngineer for accomplishment which "preeminently promotes the happiness, comfort, and well-being of humanity." Although the prize is sponsored by the Western Society of Engineers, which holds a fund now amounting to $10,000 donated by its member John W. Alvord, the award is made by a Commission representing the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the Western Society of Engineers.

The proceeds of the fund are used to provide the annual token, and to entertain the guest of honor at the annual presentation.

Although previous recipients of the award included famous men, such as Herbert C. Hoover and Orville Wright, it is the purpose of the Award Commission to bestow the award, when merited, upon comparatively little known instances of public and professional devotion. It is intended to cover all the various branches of engineering in the broadest sense, and is not limited to residents of the United States or membership in any society or organization. Members of the Institute possessed of information which they believe will be helpful to the Washington Award Commission should communicate such information to Mr. Hutchinson at Institute headquarters.

STANDARDS

Symbols for Mechanics, Structural Engineering and Testing Materials

A report on a proposed Tentative American Standard "Symbols for Mechanics, Structural Engineering and Testing Materials," is now being circulated for purposes of criticism and comment. This report has been prepared by the Subcommittee on Mechanics of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations of which the Institute is one of five joint sponsors. Those interested in obtaining copies of this report should address C. B. Le Page, A. S. M. E., 29 West 39th Street, New York, N. Y.

Proposed Model or Standard for Adequacy of Wiring of Commercial and Industrial Buildings

The Commercial National Section of the N. E. L. A. is working to establish a model or standard of adequacy, for the wiring of commercial and industrial buildings. Certain model specification paragraphs have been prepared and are intended for insertion in architects' electrical specifications. Their purpose is to provide sufficient capacity so as to permit of suitable electric lighting to meet probable demands, and avoid expense of future reconstruction. Heretofore it has been a common practise to use the National Wiring Code as a guide to adequacy, resulting in a large number of wiring installations becoming out of date shortly after completion, so that fuses are blown or the wiring drop is so excessive that lighting units fall far short of rated light output. For further details, copies of the specification paragraphs, etc. address the N. E. L. A. headquarters, 420 Lexington Ave., New York, N. Y.

World Power Conference

AMERICAN COMMITTEE APPOINTED

The engineering profession and the power developing and using industries of the United States have planned an elaborate program of papers for discussion in the sessions of the World Power Conference to be held in Berlin, June 16-25, 1930.

The papers program will stress the economic and financial problems involved in the generation, distribution and utilization of power, and focus the attention of the world upon the increasing importance of this tremendous agency in building up of civilization.

The American Committee appointed has been formulating the program, which it closed on October 21st. It is expected that

General Reports of all the papers will be available in French, German, and English, well in advance of the Congress.

The address of the World Power Conference Program Committee is Room 818, 29 West 39th Street, New York, N. Y.

Meeting of Naval Architects and Marine Engineers

The Thirty-seventh General Meeting of the Society of Naval Architects and Marine Engineers will be held in the Engineering Societies Building, 29 West 39th St., New York, N. Y., November 14-15 inclusive. A technical program of approximately fourteen papers by eminent authorities on the various subjects introduced will be presented, followed by opportunity for open discussion.

On Friday evening, November 15th, the Annual Banquet will be held in the Ball Room of the Pennsylvania Hotel, 33rd St. and Seventh Avenue, preceded by a reception at 6:30 p. m. All interested should communicate promptly with Daniel H. Cox, Secretary-Treasurer, Engineering Societies Building.

S. A. E. Transportation Meeting

The Society of Automotive Engineers will hold a Transportation Meeting, November 12-15 inclusive, at Toronto, Canada. Joint sessions with the Motor Transport Division of the American Railway Association are scheduled for November 13.

Report on Technical Discussion at Pacific Coast Convention

A summarized report of the main points in the technical discussion at the Pacific Coast Convention held in Santa Monica, Calif., September 3 to 6, is given below. The papers presented in each session are listed and followed by the discussion report. Complete discussion will be published with the respective papers in the TRANSACTIONS:

FIRST SESSION

Radio Interference for Line Insulators, E. Van Atta and E. L. White.

This paper discusses the phenomenon of brush discharge on pin type and suspension insulators, from the point of view of radio interference. It describes the various attempts at eliminating such discharge, and offers some suggestions for the future.

J. P. Jollyman stated that interference is caused by 60-kv. transformer bushings which are solid porcelain with a hole larger than the conductor. In order to eliminate the interference, his company proposes to fill the hole with metal filings or screen. Mr. Kalb stated that he has reduced such interference by installing a wire-screen sleeve between the bushing and the conductor. He said he had not been able to eliminate interference from pin type insulators by any method. He suggested that corona due to use of too small a conductor might be responsible for some interference. F. B. Doolittle stated that he has eliminated interference caused by large bushing holes by employing a brass tubing sleeve. Mr. Van Atta agreed with some of the speakers that excessive dampness minimizes interference. He stated that interference from loose bushings may be prevented by filling the open spaces with insulating compound or tape.

Spray and Fog Tests on 220-Kv. Insulators, R. J. C. Wood.

In this paper are given results of two and one-half years of tests at 150 kv. to ground under field conditions at a location near the ocean. Ten different types of insulators are compared, and a basis of comparison is suggested.

G. A. Fleming stated that his experience agreed with the contentions in Mr. Wood's paper that frequent washing of insulators is desirable in localities exposed to salt spray and sand.

The 60-Cycle Flashover of Long Suspension Insulator Strings, R. H. Angus.

This paper gives the results of an investigation covering the variations in flashover voltage for similar horizontal and vertical insulator strings with and without shields and tower members.

In commenting on Mr. Angus' paper, Bradley Cozzens pointed out that double suspension strings of insulators have a higher mortality rate than single strings of the same length.

Impulse Insulation Characteristics of Wood-Pole Lines, H. L. Melvin.

This paper gives the results of a rather comprehensive series of tests on the impulse insulation characteristics of wood and of combinations of insulators and wood used in wood-pole transmission line construction; and suggests methods of protecting wood from damage due to lightning discharges.

SECOND SESSION

Development of Insulating Oils, C. E. Skinner.

This paper traces the difficulties which have arisen during the development of insulating oils and details the precautions which are necessary during manufacture and in subsequent handling.

In discussing Mr. Skinner's paper, President H. B. Smith stated that he had raised the insulation strength of a 40,000-gallon open tank of oil by operating continuously in the bottom of the tank a 3-kv-a. electric heater. In two months, the breakdown voltage in the standard gap increased from 38,000 volts to 48,000 volts. For two months longer, it remained at 48,000 volts. Mr. Wilcox pointed out that oil which contains acid cannot be completely purified by a centrifuge or a filter press; a chemical process must also be introduced. For such oil, he advocated the use of water glass and Fuller's Earth in connection with a centrifuge. The method, he said, is simple and easily learned. D. W. Proebstel stated that he has successfully used a method of recovering used oil which employs a mixing tank, a vacuum pump and Fuller's Earth.

Effect of Tank Color on Temperature Under Service Conditions, V. M. Montsinger and L. Wetherill.

This paper outlines the results of field tests conducted on transformers, and a method of calculation to check the test results, taking into consideration the various factors which apply to a transformer. Figures are given to show that the calculated results check very closely with the observations, while the outstanding conclusion is that the color of the tanks has very little effect on the performance of transformers located outdoors, though indoors, a dark color is desirable.

In commenting on the paper, J. F. Dunn pointed out that although a black transformer tank gives an internal temperature only about 2 to 4 deg. cent. higher than a white tank, this difference is worthy of careful consideration. A difference of 2 deg., he said, may amount to 5 per cent in the loading of the transformer. He pointed out also that the temperature differences might be considerably greater in climates warmer than that of Pittsfield where the tests of the paper were conducted. J. S. Moulton stated that experiments made by him in California caused him to agree with the authors' conclusion that the color of paint is of little importance.

Population as an Index to Electrical Development, N. B. Hinson.

The value of population studies to determine the probable future electrical demand of a given community is pointed out in this paper, and a number of cases are given to show the results of such a basis of prediction.

Flames from Electric Arcs, J. Slepian.

The origin and properties of flames from electric arcs are discussed in this paper. Means for reducing and dissipating such flames are considered, and application of such means described.

Design Features That Make Large Turbine Generators Possible, W. J. Foster and M. A. Savage.

This paper discusses the modern features of electric designs which permit the development of machines having a capacity of 100,000 kv-a., or greater.

THIRD SESSION

Effects of Surges on Transformer Windings, J. K. Hodnette.

This paper describes a study of the reaction of transformer windings when subjected to transient voltage surges. Measurements of the voltage distribution to ground and between parts of windings were effected, using a cathode ray oscillograph and sphere-gaps. Stresses in the windings were estimated on the basis of surges expected on normally insulated transmission systems.

Mr. Hodnette's paper was discussed at some length by K. K. Palueff, who claimed that the shell type transformer is affected by transient voltage in the same way as the core type and that the grading of major insulation in the order of low frequencies is not a safe practise. F. W. Peek mentioned the development of a "non-resonating" transformer which, through use of electrostatic shields, is designed to make the voltage distribution uniform across a transformer winding at any frequency.

An A-C. Low-Voltage Network Without Network Protectors, L. R. Gamble and Earl Baughn.

The development of an a-c. low-voltage net-work eliminating the usual form of network protector is described, together with the operating experience obtained up to this time.

In discussing the paper, V. B. Wilfley pointed out that with the system described, two kinds of fault might possibly fail to clear themselves; namely, a secondary fault near a transformer bank and a phase-to-phase feeder fault. Mr. Gamble said that in his opinion, although tests under these particular conditions have not been made, such faults will clear satisfactorily.

Development of Low-Current High-Voltage Fuses, Roy Wilkins.

This paper covers the results of investigations and tests of a number of different forms of high-voltage fuses, together with certain comments concerning their use and limitations.

Electrical Control Features of Wind Tunnel at California Institute of Technology, W. A. Lewis, Jr.

The special electrical control features described in this paper were developed for use under conditions which must be met in making experiments with a wind tunnel having a number of unusual features.

In answer to some questions on Mr. Lewis' paper Dr. Klein stated that the closed type of wind tunnel had been selected because it requires less space; the efficiency, he said, has exceeded that of any open tunnel.

FOURTH SESSION

The Electrical Engineering of Sound Picture Systems, T. E. Shea and K. F. Morgan.

The paper describes the technique and apparatus of sound picture recording and reproduction, with emphasis on their electrica engineering aspects. The various steps in the process of disk and film recording, and the changes required in theater equipment to provide for sound production are outlined. The laboratory developments and studies out of which recording and reproduction methods have grown are given brief mention.

In discussing the paper on sound pictures, D. H. Loughran pointed out the usefulness of the cathode ray oscillograph with linear time axis.

Dial Telephone System Serving Small Communities of Southern California, F. O. Wheelock.

This paper deals with the history, use, and service of the step dial telephone system. The equipment is described and the methods of operation and maintenance are given.

Parallel Operation of Transformers Whose Ratios of Transformation Are Unequal, Mabel Macferran.

A formula is developed for use when emergency conditions necessitate the paralleling of transformer banks of unequal percentage impedance. By this formula, it is possible to calculate how far "off ratio" one bank should be placed in order to make the banks divide an anticipated peak load in proportion to their ratings.

Progress in the Study of System Stability, I. H. Summers and J. B. McClure.

This paper gives simplified methods of making transient stability calculations and includes examples demonstrating the methods used. The relation of system connections and apparatus to stability is also discussed in detail.

V. B. Wilfley, in discussing this paper, stated that he had found that excitation rises of 400 to 600 volts per sec. are more desirable and only slightly more costly than speeds of 200 volts per sec., as advocated in the paper. He warned against the possibil ty of preventing stability troubles only at the expenses of increasing circuit-breaker troubles. L. R. Gamble stated that in case of a particular station of the Washington Water Power Company, quick excitation had been found to be ineffectual. Mabel Macferran suggested caution in applying high-speed excitation to synchronous condensers. J. P. Jollyman stated that tests prove that short-circuit currents increase during many cycles after their start and that quick-acting circuit breakers are therefore desirable and less liable to trouble than slower breakers. He stated that high-speed excitation is desirable, particularly for generators with direct-connected exciters.

Synchronous Generation of Voltage Consumed by Line Inductance, T. H. Morgan.

A new plan is presented for compounding the inductive effects on transmission lines. A system of series compensation by the use of electric machinery is described. This includes an explanation of the method of producing the required voltage and inserting it into the line.

A. I. E. E. Directors Meeting

The regular meeting of the Board of Directors of the American Institute of Electrical Engineers was held at Institute headquarters, New York, on Friday, October 18, 1929.

There were present: President Harold B. Smith, Worcester, Mass.; Past-President Bancroft Gherardi, New York, N. Y.; Vice-Presidents E. B. Merriam, Schenectady, N. Y.; H. A. Kidder, New York, N. Y.; W. T. Ryan, Minneapolis, Minn.; W. S. Rodman, Charlottesville, Va.; C. E. Sisson, Toronto, Ont.; Directors I. E. Moultrop, Boston, Mass.; H. C. Don Carlos, Toronto, Ont.; E. B. Meyer, Newark, N. J.; J. Allen Johnson, Niagara Falls, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; W. S. Lee, Charlotte, N. C.; J. E. Kearns, Chicago, Ill.; C. E. Stephens, New York, N. Y.; Assistant National Secretary Henry H. Henline, New York, N. Y.

The minutes of the Directors' meeting of August 6, 1929, were approved.

A report of the meeting of the Board of Examiners held September 25, 1929, was presented, and the actions taken at that meeting were approved. Upon the recommendation of the Board of Examiners, the following actions were taken upon pending applications: 31 Students were enrolled; 89 applicants were admitted to the grade of Associate; six applicants were elected to the grade of Member; one applicant was elected to the grade of Fellow; 32 applicants were transferred to the grade of Member; three applicants were transferred to the grade of Fellow.

The Board ratified the action of the Finance Committee on approving for payment monthly bills amounting to $31,071.10. The budget for the appropriation year beginning October 1, 1929, was adopted as submitted by the Finance Committee.

The secretary reported 1020 members (950 Associates, 69 Members, and one Fellow) in arrears for dues for the fiscal year which ended April 30, 1929, and was authorized to remove from the membership list on December 1, 1929, all those whose dues remain unpaid at that time and who have not requested an extension of time for the payment of the dues.

As provided in Sec. 22 of the Constitution, Messrs. James S. Fitzmaurice, J. W. Kirkland, and Frederick G. Strong, were

added to the list of "Members for Life" by exemption from future dues.

Approval was given to the location and dates selected by the Pacific Coast members for the already authorized Pacific Coast Convention in 1930; namely, Portland, Oregon, September 2-5.

A petition from the Kansas City Section for an extension of territory was granted.

As required by the By-laws, five members of the Board of Directors were selected to serve on the National Nominating Committee, as follows: Messrs. H. C. Don Carlos, B. Gherardi, J. E. Kearns, A. M. MacCutcheon, and C. E. Stephens.

The Board confirmed the appointment by the President, of Mr. H. P. Charlesworth as a member of the Edison Medal Committee to fill the unexpired term of Mr. E. B. Craft, deceased.

The following appointments of representatives were made: Mr. H. P. Charlesworth was reappointed to the Board of Trustees, United Engineering Society, for the three-year term beginning in January 1930; Mr. W. A. Del Mar was appointed to fill the unexpired term of E. B. Craft, deceased, on the Library Board of the U. E. S., and Professor W. I. Slichter was reappointed to the Library Board for the four-year term beginning January 1, 1930; Mr. John C. Parker was reappointed a representative of the Institute on the Standards Council, American Standards Association, for the three-year term beginning January 1, 1930, and Messrs. H. H. Henline, H. M. Hobart, and H. S. Osborne were reappointed alternates on this body for the calendar year 1930.

Upon the recommendation of the Standards Committee, approval by the Institute as one of five joint sponsors was given to (1) Report of Sectional Committee on Scientific and Engineering Symbols and Abbreviations, dealing with navigational and topographical symbols, and (2) revision of American Standard for Illuminating Engineering Nomenclature and Photometric Standards, reported by the Sectional Committee on Scientific and Engineering Symbols and Abbreviations.

An invitation to send delegates to the Fiftieth Anniversary of the Elektrotechnischer Verein e. V., January 24-27, 1930, was accepted and the appointment of delegates referred to the President.

It was understood that the next meeting of the Board of Directors will be held in Chicago, December 3, during the Chicago District Meeting.

Other matters were discussed, reference to which may be found in this and future issues of the JOURNAL.

A New Evening Course at the University of Pennsylvania

A new evening course in Electrical Engineering, which will lead to the degree of Master of Science in Electrical Engineering, has been announced by Doctor Harold Pender, Dean of the Moore School of Electrical Engineering of the University of Pennsylvania. All sessions in the course will be held in the Moore School Building, Thirty-third and Walnut streets.

The course opened during the week of October 21, and any student holding a Bachelor of Arts or a Bachelor of Science degree is eligible, provided he has had the necessary preliminary instruction in mathematics and physics during his undergraduate days.

To receive the degree of Master of Science in Electrical Engineering, students must have completed an undergraduate course equivalent to that given in the Moore School, and must obtain credit within a period of four years in all subjects required for the Master of Science degree in the regular day course offered in the Moore School.

The courses required, according to Dean Pender, will be Introduction to Mathematical Physics, Advanced Electric Circuit Theory, Electron Theory and its Engineering Applications, Thesis, Fundamentals of Physical Theories, and either Atomic Structure, Electro Dynamics, or High-Frequency Alternating Current, the student having the privilege of selecting any one of the latter three.

Already eleven engineers from nearby industrial plants have signified their intention of taking the new evening course, and these men, together with others interested in the course, will be given an opportunity to discuss its various details with Moore School faculty members at a preliminary meeting for registration and consultation to be held in Room 212 of the Moore School Building, October 18.

Further information may be obtained from the Office of the Dean, Moore School.

General Lytle Brown Appointed Chief of Engineers

Of interest to almost every engineering organization in the United States is the recent selection of a new Chief of Engineers to succeed Lieutenant-General Edgar Jadwin who retired August 7. After careful investigation, lasting over a month, in which he reviewed the advice and recommendations of almost every shade of opinion interested in the selection of the chief, President Hoover appointed Brigadier-General Lytle Brown Chief of Engineers, U. S. Army, and the Senate promptly confirmed the appointment.

General Brown is a graduate of Vanderbilt University, West Point and the General Staff College at Fort Leavenworth. He is also a Charter Member of the Society of American Military Engineers.

In accordance with plans which President Hoover had announced at the same time of General Brown's appointments, a slight reorganization is taking place in the Corps of Engineers. Eight geographic divisions have been formed, several of the old engineering districts having been regrouped and reassigned. The geographic divisions, their chiefs, with headquarters and fields of operation are:

Lower Mississippi Valley Division, System and flood control in the Alluvial Valley, Chief, Brigadier-General T. H. Jackson, Vicksburg, Miss.

Upper Mississippi Valley Division, (Upper Mississippi System, including the Missouri, Illinois and Ohio River) Chief, Lt. Col. G. R. Spalding, St. Louis, Mo.

Great Lakes Division, (harbors and channels on the Great Lakes; waterway from Great Lakes to the Atlantic) Chief, Col. E. M. Markham, Cleveland, Ohio.

North Atlantic Division, (harbors and channels along the North Atlantic Coast, Cape Cold Canal, Delaware and Chesapeake Canal, harbors and channels in Porto Rico), Chief, Col. William J. Barden, New York City.

South Atlantic Division, (harbors and channels along the South Atlantic Coast, intracoastal waterways from Norfolk, Va. to Jacksonville, Fla), Chief, Col. H. B. Ferguson, Norfolk, Va.

Gulf of Mexico Division, (harbors and channels along Gulf Coast and in Florida, intracoastal waterways from New Orleans, La. to Corpus Christi, Texas), Chief, Lt.-Col. Mark Brooke, New Orleans, La.

South Pacific Division, (harbors and channels along California coast and in Hawaii, Sacramento River flood control), Chief, Lt.-Col. J. Franklin Bell, San Francisco, Calif.

North Pacific Division, (harbors and channels along the coast of Oregon, Washington and Alaska, Columbia River system), Chief, Col. Gustave R. Lukesh, Portland, Ore.

Col. Edward H. Schulz, Corps of Engineers, has been assigned to the command of the Engineer Post and School at Fort Humphreys, Va., succeeding Col. E. M. Markham.

The John Fritz Medal to Doctor Modjeski

Ralph Modjeski, a native of Poland, and son of the late Helen Modjeska, noted tragedienne, was awarded the 1929 John Fritz Gold Medal, at the regular annual meeting of the Board, Sep-

tember 27, 1929, "For notable achievement as an engineer of great bridges combining the principles of strength and beauty."

The choice of Doctor Modjeski was unanimous with the Board of Award, composed of sixteen past-presidents of the four national societies of civil, mining and metallurgical, mechanical, and electrical engineers, representing a combined membership of nearly 60,000.

"In recognition of the increasing contribution of bridge builders to the progress of humanity, and in appreciation of the distinguished scientific and industrial achievements of Doctor Modjeski as one of America's foremost bridge builders, this award was made."

Born in Cracow in 1861, Doctor Modjeski came to this country with his parents in 1876. He obtained his engineering education at the Ecole des Ponts et Chaussees in Paris. As designer, construction engineer, and consultant, he has been identified with many of America's most notable bridges, among them the McKinley Bridge over the Mississippi at St. Louis, Columbia River Bridge at Celilo, Oregon, Keokuk Bridge over the Mississippi, Ohio River Bridge at Cincinnati, Thames River Bridge at New London, Quebec Bridge, Poughkeepsie Bridge, Philadelphia-Camden Bridge, and Manhattan Bridge, New York.

Members of the Board making the award were; Robert Ridgway, George S. Davison, John F. Stevens, and Lincoln Bush, of the American Society of Civil Engineers; J. V. W. Reynders, Samuel A. Taylor, E. De Golyer, George Otis Smith, of the American Institute of Mining and Metallurgical Engineers; D. S. Jacobus, Dexter S. Kimball, Charles M. Scwab, and Alex Dow, of the American Society of Mechanical Engineers, and M. I. Pupin, C. C. Chesney, Bancroft Gherardi, and R. F. Schuchardt, Past-Presidents of the Institute.

Book Reviews

Television. By H. Horton Sheldon and Edgar N. Grisewood. New York, D. Van Nostrand Company, Inc. 194 pages, 5½ x 8¾ in., cloth, illustrated, 1929. Price $2.75.

The authors describe in language easily understood the developments and present limitations of this newest branch of the electrical communication art. Under a broad definition of television, which consists of reducing an object to a series of light signals which are converted into electric signals, transmitted to a distance, and converted back into light signals, the authors include in their work both the transmission of pictures and the scanning of objects. The transmission of photographs, or telephotography, which is described, has attained a commercial status, and this service is now regularly supplied by the large telegraph companies. The various systems of scanning, which are also described, are still in the experimental laboratory stage and the future of television, while seeming assured, is still problematical. This book, which comes as the first American work on this subject, gives a historical outline of developments and explains the essential elements of television. It also describes and illustrates the apparatus used by different inventors in this field. The book is addressed particularly to amateurs in the belief that widespread amateur interest will prove of great help in the development of the art.

Proceedings, International Congress on Illumination, 1928. Chemical Publishing Company, Easton, Pa. 1458 pages, 6½ x 9¼ in., cloth, illustrated. Price $10.00. Apply for copies to Illuminating Engineering Society, 29 West 39th Street, New York, N. Y.

The Proceedings of the International Congress on Illumination, 1928, includes the proceedings of the Seventh Plenary Session of the International Commission on Illumination held at Saranac Inn, N. Y., September, 1928, and also selected papers presented at the Twenty-third Annual Convention of the Illuminating Engineering Society. Theme subjects treated at length are Street Lighting, Glare Research, Motor Vehicle Headlighting, Distribution of Luminous Flux, Precision Photometry and Standards, Heterochromatic Photometry, Natural Lighting, Decorative Lighting, Vocabulary, Definitions and Symbols, School and Factory Lighting, Illumination Research, Colored Signal Glasses, Diffusing Materials, Motion Picture Lighting, the I. C. I. Tour, general sessions reports and the results of an international survey on show-window lighting, home lighting, lighting education and aviation lighting practise. In all, the volume contains sixty-nine papers and reports by authors recognized as the leaders in illumination throughout the world.

The vast amount of authoritative information contained in the Proceedings will prove an invaluable reference source to those who wish to continue research along these lines and also to illuminating engineers whose daily activities bring them into close touch with many problems in lighting practise.

The volume is indexed and cross-indexed as to contents and personnel, and is profusely illustrated with line-cut and half-tone engravings and color plates. The scope of the contents and the manner in which the most involved subjects are reported serve to illustrate the present status and the broad scope of the art and science of illumination.

Elementary Differential Equations. By Thornton Foy. New York, N. Y., D. Van Nostrand Company, Inc. 255 pages, 6¼ x 9¼ in., cloth, illustrated, 1929. Price $2.50.

This text is the outgrowth of several mimeographed editions used by the author in the out-of-hour courses at the Bell Telephone Laboratories, and has been written primarily for engineering students. It deals with the solution of ordinary differential equations, especially those linear equations commonly encountered in the study of physics. In order to help visualize abstract mathematical expressions, the fundamental ideas are interpreted in geometrical illustrations which will be found very helpful. A large number of practical problems is given and, being written especially for engineers, subjects of purely mathematical interest have been omitted.

Industrial Standardization. Published by the National Industrial Conference Board, New York, N. Y. 306 pages, 6 x 8¾ in., cloth. Price $3.50.

The purpose of this book is to establish a popular understanding of industrial standardization and the extent and manner in which it is being advanced. The recent rapid industrial growth in the United States is attributed largely to the influence of standardization in almost every branch of American business. Part I covers the historical background of standardization and gives a picture of the issues involved in the adoption of standard practises and devices and the procedure followed by companies, technical societies, trade associations and other standardizing bodies. Part II deals with the advantages and business savings resulting from standardization. While the full effects of standardization cannot yet be evaluated, the cumulative evidence points to the conclusion that it is an important factor in increasing industrial efficiency and that it suggests unlimited possibilities for future achievements. While the technical literature on standardization is extensive, this is perhaps the only work which considers the entire subject in a broad, popular, and non-technical manner.

Introduction to College Physics. By C. M. Kilby. New York, N. Y., D. Van Nostrand Company, Inc. 349 pages, 5¾ x 8¾ in., cloth, illustrated, 1929. Price $3.00.

The fundamentals of physics are arranged in a concise and accurate manner in this textbook which is designed for use as first year college course, and the subject is covered in a way which comprises a good foundation for future study. The contents are divided into five major parts; *viz.*, mechanics, magnetism and electricity, heat, sound, and light. The book is liberally illustrated with diagrams, and special stress is laid on the solution

of problems which are given in considerable numbers. Many complete solutions of problems are given as guides. While it is elementary in scope, it offers a very good groundwork for the beginner in the study of physics.

FORTY YEARS WITH GENERAL ELECTRIC. By John T. Broderick. Albany, N. Y., Fort Orange Press. 218 pages, 5¼ x 7¾ in., cloth, illustrated, 1929. Price $2.50.

The book contains a rather sketchy history of the General Electric Company, combined with many biographical references to the men who have been leaders in the development of the organization. The author's long connection with the company has enabled him to produce a human interest story of people and events with which he has been intimately associated. The author designates as fathers of the General Electric Co., Elihu Thomson, C. A. Coffin and E. W. Rice, Jr. who, surrounded by able and brilliant colleagues, established business ideals which comprise the spirit of a great corporation. Many of the company's notable achievements in research are described and numerous incidents in connection with the business are narrated in interesting style.

AN INTRODUCTION TO CRYSTAL ANALYSIS. By Sir William Bragg. New York, N. Y., D. Van Nostrand Company, Inc. 168 pages, 5¾ x 9 in., cloth, illustrated, 1929. Price $4.25.

This is an American edition of an English book which describes the methods of examining the crystalline structure of solid matter. The development of X-rays for this purpose was the outgrowth of experiments to prove that X-rays and light waves were of the same nature. The crystalline structure of materials is of importance to many sciences and since a method of crystal analysis has become available great progress has been made in this field. The contents includes reflection by the crystal lattice, description of methods of analysis, simple inorganic crystals, space groups or crystal arrangements, some complex crystals, and a final chapter devoted to X-ray analysis of the structure of metals and alloys.

PERSONAL MENTION

WILLARD A. LANING, JR., has been appointed Research Graduate Assistant at the Engineering Equipment Station, University of Illinois, Urbana, Ill.

R. BIGLAND DICKINSON, who for four years was with the Duke Price Power Company, Limited, in Arvida and Isle Maligne, P. Q., has engaged as Assistant Superintendent on construction work with the Canadian Comstock Company in Montreal.

A. ANDREW DOUGLAS, for the past three years an instructor for the Brooklyn Edison Company Educational Bureau, is now at the State University of Iowa, Iowa City, Iowa, taking graduate work in electricity and mathematics.

CLAIR F. BOWMAN has resigned his position as Instructor in Electrical Engineering at Purdue University to accept the position of Assistant Professor in Electrical Engineering at Montana State College, Bozeman, Mont.

JUSTIN J. MCCARTHY, formerly Research Engineer of the Cleveland Railway, is now connected with the engineers, Parsons, Klapp, Brinckerhoff & Douglas, of Cleveland, Ohio, as Signal Engineer.

JOHN E. S. THORPE, heretofore General Superintendent of the Knoxville Power Company, Calderwood, Tennessee, has accepted the office of President of the Nantahala Power & Light Company, Bryson City, N. C.

THOMAS A. FAWELL has recently severed his connection as manufacturers representative of the Martindale Electric Company and other manufacturers and is associated with the Hoffman Specialty Company, Inc., with headquarters at 557 Market Street, San Francisco, Calif.

CLARENCE L. COLLENS, President of the Reliance Electric and Engineering Company and Associate of the Institute, has been elected President of the National Electrical Manufacturers Association for the ensuing year. Mr. Collens received the McGraw Award for his part in bringing about the organization of NEMA three years ago and has been Governor of the Association and Vice-President of the Policies Division ever since its inception.

A. W. BERRESFORD, President of the American Engineering Council, Past-President of the Associated Manufacturers of Electrical Supplies, Electrical Manufacturers Club, and the American Institute of Electrical Engineers, was appointed Managing Director of NEMA, effective at once, to succeed Mr. Alfred E. Waller resigned. Mr. Berresford was formerly Vice-President and General Manager of the Cutler-Hammer Mfg. Co. and Vice-President of what is now the Kelvinator Corporation.

Obituary

Henry C. Houck, Manager of the Merchandise Department of the General Electric Company, died at his home in Bridgeport, Conn., on October 15, after a long illness. Educated at Phillips Exeter Academy and the University of Pennsylvania, from which he was graduated in Electrical Engineering in 1899, he enteredt he employ of the General Electric Company in the fall of that year. In his thirty years of service with the company, Mr. Houck filled many important positions at Schenectady, Cleveland, and Cincinnati, as well as at Bridgeport, where he became Manager of the Merchandise Department in December, 1925. He was made an Associate of the Institute in 1907.

Bedford Jethro Brown, Superintendent of the Meter Department of the Duke Power Company, Charlotte, N. C., died October 2, 1929. He was a native of Charlotte, and received his public school education there. He was graduated with the degree of B. E. in Electrical Engineering from the N. C. A. & M. College, Raleigh, N. C. in 1901, after which he completed an apprentice course in engineering with the Westinghouse Electric & Manufacturing Company. From the latter part of 1903 to March 1904 he was in the Testing Department of the Westinghouse Company and then became a Meter Expert in the Company's Chicago District. He was compelled to leave this position because of ill health, and did not resume his work again until 1906 when he accepted a position in the Meter Testing Department of the Southern Power Company at Charlotte, N. C.

Mr. Brown's work led to extensive travel in the United States, notwithstanding the fact that for eleven years he was Superintendent of the Testing Department and Instrument Testing Laboratory of the Westinghouse Company. He joined the Institute as an Associate in 1910 and became a Member in 1918.

Charles Shelly Lawson, Assistant Manager of the Transformer Engineering Department of the Sharon plant of the Westinghouse Electric and Manufacturing Co., died at the Buhl Hospital, Saturday, October twelfth, following an operation.

Mr. Lawson was taken suddenly ill on Monday, at the Sharon Country Club links.

Born on a farm near Montgomery, Ala., February 8, 1879, he was graduated from University of Alabama with an M. S. degree, and in 1902 he received a B. S. in Electrical Engineering from Massachusetts Institute of Technology. He then took the Student Course of the General Electric Company and later became associated with the Atlanta Water and Power Company. In 1905 Mr. Lawson accepted a position as Insulation Engineer in the Transformer Engineering Department of the East Pittsburgh Plant of the Westinghouse Company, and from that time his rise was rapid, ultimately becoming assistant mana-

ger. He came to Sharon in 1925. He was a Fellow of the Institute, which he joined in 1906; was a member of the Sharon Rotary and Country Clubs and the Sharon Chamber of Commerce.

N. Govindraj, Mains Superintendent, Simla Municipal Electricity Department, Simla, North India, died September 21 at Simla, of penumonia.

He was a graduate in Electrical Engineering from the Victoria Jubilee Technical Institute, at Bombay, and was the recipient of the Lord Reay Gold Medal of the Institute. He had served with the Tatas at Bombay as an apprentice, and after a short term of service with the Bombay Tramways, he was appointed Mains Superintendent of the Simla Municipality in 1920, an office which he has filled with highest efficiency.

Mr. Govindraj was thirty-eight years of age and a native of Madras, India. In his early training he was a student of physics, chemistry and natural science at Madras University, and in his preliminary electrical work he was with the maintenance and operation departments of a receiving station, inspecting transformers, high-voltage motors and other switching apparatus. He later was made superintendent of erection and maintenance of extra high-tension aerial mains and the laying and maintaining of high- and low-tension cables. He joined the Institute as an Associate in 1922.

Wallace S. Clark, form any years head of the Wire and Cable Division of the General Electric Company, died suddenly at his home in Schenectady, N. Y., on October 11. Mr. Clark was one of the pioneers of the electrical industry, and his service in it began in September, 1885, when, shortly after his graduation from Sheffield Scientific School with the degree of Ph. B., he entered the commercial and engineering offices of the Edison Electric Light Company at 65 Fifth Avenue, New York.

He went to the Schenectady Works of the Edison General Electric Company in February, 1887; the company had moved to that city the previous fall. He entered the Wire and Cable Department of the Company in 1891, and in 1903 was made superintendent of the wire and cable, underground tube and varnish departments. In July, 1904, he was made engineer of the wire and cable department, and was also in charge of sales for the department. With the formation of the central station department in 1924, he was made manager of the wire and cable division. During the entire period of the participation of the United States in the World War, Mr. Clark served on the war service committee of the insulated wire industry. He joined the Institute in 1902.

James Thomas Watson of the Westinghouse Electric & Mfg. Co., and with residence at Wilkes Barre, died September 17, 1929. He was born at Fallston, Harford County, Maryland, and after one year in the Waynesboro Business College, Waynesboro, Va., and three and a half years at the Fishburne Military School, (also at Waynesboro,) he became a student of the International Correspondence School at Scranton, graduating from a course in Electric Power and Lighting, and further pursuing his study of Electrical Engineering with the American School of Correspondence at Chicago.

From 1897 to 1899 he was Electrician in Charge of the Waynesboro Electric Light & Power Company, Waynesboro, Va. He then became Foreman of Interior Wiring for Charles B. Scott, Electrical Contractor at Scranton, Pa., where he remained until 1900, when he was chosen Chief Foreman of Electricians by the Delaware and Hudson Company Scranton, Pa. remaining there eight years. The last three years of his period of service he was Assistant to the Electrical Engineer. Later in the year 1908 he became Superintendent of the Blue Ridge Light & Power Company, Staunton, Va. and then Electrical Engineer of the Tennessee Copper Company, Copperhill, Tenn. Mr. Watson became an Associate of the Institute in 1910 and was transferred to the grade of Member in 1913.

David L. Huntington, President of the Washington Water Power Company, Spokane, Washington, to which office he rose from General Manager and Chief Engineer in 1902, died at his home September 27 after a confinement of two years. He was born in New London, Connecticut, received his public school education in Washington, D. C. and afterward attended Yale University. Upon leaving Yale, he joined the Thomson-Houston Electric Company, Lynn, Mass. and when the General Electric Company was organized, he was sent to the Philadelphia District. He resigned from this work to become Treasurer of the Washington Water Power Company.

Mr. Huntington was prominently identified with electrical developments of the Northeast and was an important factor in the growth of the Spokane utility movement. His last big undertaking was as head of the Washington Water Power Company in building the Chelan hydroelectric plant in connection with which he made several trips to New York, personally supervising the purchase of the site, the awarding of contracts and the formulation of the financial program. Although taken ill before the completion of the work, through the agency of an electric button, he placed this first unit in operation. He joined the Institute as an Associate in 1902 and was elected a Fellow in 1913. In commenting upon his death, the *Spokesman Review* of Spokane said, "Mr. Huntington might be said to have anticipated the public policy, now the rule rather than the exception among public utility corporations of foresight and aggressiveness, that service is the yardstick of usefulness."

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, together with the addresses as they now appear on the Institute records. Any member knowing the present address of any of these members is requested to communicate with the Secretary at 33 West 39th St., New York.

All members are urged to notify Institute Headquarters promptly of any changes in mailing or business address, thus relieving the member of needless annoyance and assuring the prompt delivery of Institute mail through the accuracy of our mailing records, and the elimination of unnecessary expense for postage and clerical work:

C. A. Baer, 1330 Pine St., Philadelphia, Pa.
J. B. Bakker, 440 Hyde St., San Francisco, Calif.
Marcel A. Collinot, c/o F. W. V. Rm. 1050, 11 W. 42nd St., New York, N. Y.
H. H. DeCamp, 414 Ella St., Wilkinsburg, Pa.
F. S. Degener, 1015 Casgrain Ave., Detroit, Mich.
Ernest Fick, A. T. & T. Co., 412 S. Market St., Chicago, Ill.
Henry W. Harbison, R. F. D. 1, Merriam, Kans.
John Ernest Hardey, Box 1055, Wellington, N. Z.
H. U. Hedeby, P. O. Box 414, Sharon, Pa.
Eric David Howells, Westinghouse Club, Wilkinsburg, Pa.
Edgar A. James, 912 S. Poplar St., Allentown, Pa.
E. H. Kirkland, Jr., 6701 Cregier Ave., Chicago, Ill.
F. A. Klein, 1215 Locust St., Philadelphia, Pa.
Charles Max, Companhia Electrica, Catumbela, Angola, W. Africa.
John T. Mooney, 4547 N. Leavitt St., Chicago, Ill.
Julius M. Najman, 1703 15th Ave., South, Birmingham, Ala.
H. L. Perkins, 129 Marshall St., Petersburg, Va.
W. M. Philip, 433 Morrison St., Niagara Falls, Ont., Can.
H. D. Rives, 298 Central Ave., Lynbrook, L. I., N. Y.
Carl Schwartz, c/o Int'l. Combustion Engg. Corp., New York, N. Y.
Robert H. Singer, 2214 Auburn Ave., Cincinnati, Ohio.
Gerhard Svensson, c/o American Express Co., 65 Broadway, New York, N. Y.
C. H. Willis, 184 Prospect Ave., Princeton, N. J.

A. I. E. E. Section Activities

WONDERS OF SOUND TRANSMISSION

New York Section to hear S. P. Grace of Bell Telephone Laboratories

On the evening of Friday, November 8th, the New York Section members will have the privilege of attending a lecture and demonstration by S. P. Grace, Asst. Vice-President of the Bell Telephone Laboratories, Inc. disclosing some of the most recent wonders of science in the field of sound transmission. Just a glance over the modern marvels to be illustrated and explained will reveal the electric ear, scrambled speech, delayed speech, double-ended short wave high power radio tubes, amplified muscle noises, translation of mechanical impulses into speech, the artificial larynx, and so on down the list of the latest work in sound transmission—the results of organized effort to extend the range of the human voice. Mr. Grace has shown that he can entertain audiences of every type, scientists and laymen. The Program Committee feels that this is an unusual opportunity to spend not only a particularly interesting and instructive evening, but it is as sure that all will go away with a fuller realization of the place of science in American progress. The meeting will be held at 8 p. m. in the Engineering Auditorium, 33 West 39th Street, New York, N. Y.

NEW YORK SECTION TRANSPORTATION COMMUNICATION GROUPS HOLD MEETINGS

The group activities within the New York Section for the year 1929-30 are now well under way. Of the four groups which have been organized to date, the Power Group met on October 30th, the Transportation and Communication Groups are scheduled for November 4th and November 13th, respectively. The Illumination Group is arranging its first meeting for January 7, 1930. The general details of the November 4th and 13th meetings, which will be held in the Engineering Societies Building, 33 West 39th St., New York, N. Y., follow:

Transportation Group: Meeting Monday, November 4, 1929 at 7:30 p. m., Room 1, 5th Floor, Engineering Societies Building. Subject—*How the Electric Railways are Meeting the Demand for Modern Transportation.* Speakers: Guy C. Hecker, General Secretary, A. E. R. A. and B. O. Austin, Control Engineer, Westinghouse Elec. & Mfg. Co. The speakers will outline the many technical developments of interest to engineers that have occurred recently.

Communication Group; Meeting Wednesday, November 13, 1929 at 7:30 p. m., Room 2, 5th Floor, Engineering Societies Building. Subject—*Materials of Communication.* Speakers: W. W. Brown, General Electric Co. on Micalex. *Its properties and Application to Radio Equipment.* I. R. Smith, Westinghouse Elec & Mfg. Co. on *Copper Oxide. Its Use and Performance in Rectifiers.* W. Fondiller, Bell Telephone Laboratories on *Developments in Communication Materials.* The work done on insulating materials and metals, including duralumin, permalloy, brasses and bronzes. D. Levinger, Western Electric Co. on *Manufacturing Problems in Communication Materials.* Problems in introducing some of the newer materials into manufacture.

There will be open discussion at all group meetings, which will all be scheduled for 7:30 p. m. sharp with adjournment at 9:30 to enable the commuting members to get early trains.

FUTURE SECTION MEETINGS

Akron

November 8, 1929 at Canton. *Heavy Duty Mercury Arc Rectifiers*, by O. K. Marti, Chief Engineer, American Brown Boveri Electric Corporation.

December 31, 1929. *Railway Electrification*, by J. V. B. Duer, Electrical Engineer, Pennsylvania Railroad Company.

Cleveland

November 21, 1929. Subject: Social and Economic Results of Power and Machinery. Speaker: C. M. Ripley, General Electric Co.

December 12, 1929. Subject: Anti-Aircraft Artillery. Speaker: Major C. M. Barnes, Ordnance Dept., United States Army.

Detroit-Ann Arbor

November 12, 1929. Hayes Hotel, Jackson, Michigan. Subject: Power System Planning. Speaker: L. W. W. Morrow, Editor, *Electrical World*, New York.

December 10, 1929. The Detroit Edison Auditorium. Joint meeting with the Detroit Engineering Society. Subject: Power House Design. Speaker: Alex Dow, President of the Detroit Edison Co. Inspection trip through the New Delray Power House in the afternoon.

Lynn

November 6, 1929. Technical Lecture by L. A. Hawkins, Executive Engineer of Research Laboratory, General Electric Co. Subject: "Today's Science, Tomorrow's Engineering."

November 20, 1929. Popular Lecture "With Allenby in Palestine and Lawrence in Arabia" by the noted lecturer Lowell Thomas. Ladies invited.

December 4, 1929. Technical Lecture by H. D. Brown (*Mercury Arc Rectifiers*).

Pittsburgh

November 19, 1929. *What's Coming in Aviation*, W. B. Stout, Stout Metal Airplane Company, Division Ford Motor Company.

December 10, 1929. *Latest Developments in Supervisory Control*, R. J. Wensley, Westinghouse Electric & Mfg. Company, Mansfield, Ohio.

IOWA SECTION ORGANIZED

At a meeting held on June 25, 1929, the Board of Directors authorized the organization of the Iowa Section. C. L. Sampson, Engineer of Transmission, Protection, and Foreign Wire Relations of the Northwestern Bell Telephone Company, Des Moines, Iowa, was elected Chairman and Professor J. K. McNeely, Iowa State College, Ames, Iowa, was chosen as Secretary.

The Iowa Section includes as its territory the entire state of Iowa.

MEETING OF EXECUTIVE COMMITTEE OF MIDDLE EASTERN DISTRICT

A meeting of the Executive Committee of the Middle Eastern District, No. 2, held at the Keystone Athletic Club, Pittsburgh, Pa., on October 7, was attended by a large majority of the members of the Committee, and ten of the twelve Sections in the District were represented.

After the completion of the business before the meeting, there was an extended discussion of Section activities and methods by which they may be made more effective. Some of the more important topics were; the desirability of affording to as many members as possible opportunities for participating in the activities; use of cards to keep records of attendance at meetings; developing better speaking ability among the members; methods of making special appeal to enrolled Students of the Institute; stimulation of discussion; policies regarding local membership; meetings of certain technical groups within a Section; the types of social meetings which are most helpful; civic affairs; and publicity.

PAST SECTION MEETINGS

Boston

Meeting of Executive Board. Election of Membership, Program and Entertainment Committee Chairmen. Voted to hold the regular monthly meetings on the first Tuesday of each month. The Secretary announced the plans for the October meeting, an inspection trip of the Boston Harbor on the City Steamship, Saturday afternoon, Oct. 5. Discussion of membership policy for the coming year. Approval of tentative budget for the year. September 19.

Chicago

Joint meeting with Western Society of Engineers held during celebration of Light's Golden Jubilee. L. A. Ferguson, Vice-President, Commonwealth Edison Co., read his speech at the commemoration of the 50th anniversary of the laying of the Atlantic cable made in N. Y. twenty years ago. Speech by W. L. Abbott, Chief Operating Engineer, Commonwealth Edison Co. on the old days in Chicago. The meeting was preceded by a dinner. September 23. Attendance 385.

Cincinnati

Minutes of annual meeting and Treasurer's report read and approved. Professor A. M. Wilson, head of the Department of Electrical Engineering at the University of Cincinnati, gave a brief analysis of color projection and color filters, with demonstrations. September 17. Attendance 76.

Denver

"The Quest of the Unknown," by Professor Harold B. Smith, President of the Institute, illustrated with lantern slides. A dinner preceded the meeting. September 11. Attendance 46.

Talk by F. C. Hanker, Manager Central Station Engineering, Westinghouse E. & M. Co., "Recent Studies in Generation and Distribution of Power." Talk was illustrated and discussed by Professor W. C. DuVall, Counselor of the University of Colorado Branch. The meeting was preceded by a dinner. October 4. Attendance 47.

Detroit-Ann Arbor

Chairman L. F. Hickernell reported on the Executive Committee meeting of the Great Lakes District (No. 5) held in Chicago. J. J. Shoemaker, Chairman of the Meetings and Papers Committee, presented the complete program of the 1929-1930 meetings. Talk by John T. Millen, Director of the Detroit Zoological Park, on the subject, "Wild Animal Experiences." Annual dinner meeting at the Lee Plaza Hotel. September 17. Attendance 91.

Erie

Discussion of proposed amendments to Erie Section Constitution. Talk by H. M. Towne, Engineer in charge of Design and Development of Lightning Arresters for General Elec. Co. at Pittsfield, Mass., on "Lightning Problems." Dinner preceded the meeting. September 24. Attendance 60.

Houston

Hezzie Clark, Humble Pipe Line Co., gave a talk on electrification in the petroleum industry. Discussion followed and M. E. Montrose of General Elec. Co. presented figures in reference to the cost of using electricity instead of steam for the drilling of wells. Also talks by J. H. Dubendorf, Shell Petroleum Co., on electrification of oil refineries and D. A. Keirn of the Westinghouse Co. on the photoelectric cell. Discussion followed. September 26. Attendance 63.

Iowa

First meeting of this newly authorized Section of the Institute. Election of officers as follows: C. L. Sampson, Chairman, J. K. McNeely, Secretary-Treasurer, John M. Drabelle and G. T. Shoemaker, members of the Executive Committee. Address by President Harold B. Smith on "The Quest of the Unknown." September 13. Attendance 44.

Kansas City

"The Quest of the Unknown" delivered by Professor Harold B. Smith, President of the A. I. E. E. An informal dinner preceded the meeting at which the executive committees and presiding officers of each of the technical societies as well as the leading men from the Westinghouse, General Electric, Western Electric, Allis-Chalmers, the large utilities of the Middle West, and the Deans of the Engineering Schools in the vicinity were present. September 16. Attendance 126.

Lehigh Valley

Annual meeting. At 10:00 a. m. inspection trip through No. 5 Breaker of the Jeddo-Highland Coal Co. 12:00 noon Luncheon at the Altamont. 2:00 p. m. business meeting, election of officers. Paper by A. O. Austin of the Ohio Brass Co., on *Power Transmission and High Voltage Insulators.* Moving pictures at the Service Depot on "Formation of Coal During the Ages Past." 6:30 p. m. dinner at Hotel Altamont. Address by Stephen Q. Hayes of the Westinghouse Company on "Electrifying South America." June 1. Attendance 101.

Los Angeles

First meeting of fiscal year. New officers and members of the Executive Committee were introduced. H. L. Caldwell gave a report of the Swampscott convention. E. R. Northmore gave a report of the Pacific Coast Convention. Past-President R. F. Schuchardt, H. B. Gear, Asst. to the Vice-President, Commonwealth Edison Co. and O. C. Merrill, Chairman of the American Committee of the World Power Conference, who were passing through Los Angeles enroute to the World Engineering Congress at Tokio, Japan, gave a few remarks. Professor R. W. Sorensen, California Institute of Technology talked on the subject "A Western Engineer's Experience in the East." Professor Sorensen also briefly discussed the paper which he presented before the meeting of the Society for the Promotion of Engineering Education, outlining certain phases of the work at the California Institute of Technology. The meeting was preceded by a dinner at the Engineers' Club. October 8. Attendance 78.

Louisville

General Section matters discussed. W. H. Stilwell, Signal Engineer of the Louisville and Nashville Railroad Co., talked on "Centralized Traffic Control Developed by the General Railway Signal Co." Four reels of motion pictures taken of the Centralized Traffic Control installed on the Ohio Central Lines were shown. October 8. Attendance 60.

Madison

Proposed new By-laws of Section distributed among members. Professor Edward Bennett spoke on "The Inadequacy of the Public Utilities Law of Wisconsin." Dinner at the Memorial Union preceded the meeting. October 9. Attendance 44.

Mexico

Election of officers as follows: G. Solis Payan, Chairman; E. Leonarz, Jr., Secretary; E. F. Lopez, Treasurer. Executive Committee: F. Aubert, H. Olmedo, G. Obregon, B. M. Antipovitch.

Minnesota

First meeting of the season. John Lapham of the North Central Electric Association spoke on "Edison and Light's Golden Jubilee." Several slides were shown. Two moving pictures entitled, "The Benefactor" and "The Light of a Race" were presented. October 3. Attendance 45.

Pittsburgh

Inspection trip to the Bell Telephone Plant. Refreshments were served at the conclusion of the inspection. September 18. Attendance 275.

Portland

"The Quest of the Unknown," by Professor Harold B. Smith, President of the Institute, illustrated with lantern slides. The meeting was preceded by a dinner. At the conclusion of the evening meeting a buffet lunch was served. August 26. Attendance 95.

Executive business: Chairman H. H. Cake announced that the Executive Committee of the Section made a formal request through Vice-President G. E. Quinan of District No. 9 that the date of holding the 1930 Pacific Coast Convention be Sept. 2-5, inclusive. H. H. Schoolfield was selected as general convention chairman. Mr. Schoolfield reported briefly on the success of the Santa Monica Convention. I. H. Summers of the Central Station Engg. Dept. of the General Electric Co., Schenectady, N. Y. gave a résumé of a paper presented at the Pacific Coast Convention entitled, *System Stability.* Buffet lunch followed the meeting. September 24. Attendance 69.

Rochester

Dr. Phillips Thomas and Dr. C. K. Lee, both of the Westinghouse E. & M. Co., East Pittsburgh, Pa., spoke on "Recent Developments in the Research Departments of the Westinghouse Elec. & Mfg. Co." Meeting was held jointly with the Rochester Engineering Society. The meeting was preceded by a dinner given to welcome the speakers. October 4. Attendance 283.

St. Louis

Past Chairman C. P. Potter called the 212th meeting of the Section to order and gave a report covering his term of office. G. H. Quermann, Chairman for the year 1929-1930, made a few remarks covering his policies and also his attendance at the Summer Convention. Chairmen of the Standing Committees were announced. Professor Harold B. Smith, President of the Institute then gave an address on "The Quest of the Unknown." Attendance prizes were awarded. Sandwiches and coffee were served. September 17. Attendance 85.

San Francisco

"The Quest of the Unknown," delivered by President Harold B. Smith. An informal dinner preceded this meeting. Plans for the September meeting were announced. August 29. Attendance 145.

Seattle

Annual banquet. Reading of the minutes was postponed. J. Hellenthal, Secretary District No. 9 gave a short report of the Pacific Coast Convention at Santa Monica, Calif. Sept. 17. Attendance 46.

Sharon

F. D. Newbury and R. S. Marthens, both of the Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa., spoke on the subject, "The Probem of Designing Fabricated D. C. Motors and Generators." Two motion picture reels preceded the talks. October 1. Attendance 124.

Springfield

General Section matters reviewed. Hans Passburg, Engineer of the United Electric Light Co., Springfield, Mass., spoke on the subject "Muscle Shoals." Mr. Passburg went into detail regarding the Muscle Shoals development and illustrated his talk with many lantern slides. September 9. Attendance 23.

Toledo

The minutes of the previous meeting were read and approved. The Program Committee reported regarding its activities. Mr. Paul Gravelle, Results Engineer of the Toledo Edison Co., spoke on "Modern Steam Plant Economies." A large drawing of the Acme Station was used to trace out the heat cycles in the turbines, boilers and auxiliaries. Discussion followed. September 24. Attendance 28.

Toronto

Annual Get-Together meeting. Review of general Section matters after which the remainder of the evening was of a social character with music, entertainment, and refreshments. September 27. Attendance 73.

Utah

"The Quest of the Unknown," by Professor Harold B. Smith, President of the A. I. E. E. September 9. Attendance 44.

A. I. E. E. Student Activities

A STUDENT BRANCH AT UNIVERSITY OF NEW MEXICO

At its meeting held on May 22, 1929, the Board of Directors authorized the formation of a Student Branch at the University of New Mexico, Albuquerque, New Mexico. The Branch has organized and selected the officers named below:

F. A. Stortz, Jr., Chairman
R. D. Jenkins, Vice-Chairman
W. Irving Abbott, Secretary-Treasurer

Professor F. M. Denton has been appointed Counselor of the Branch.

STUDENT BRANCH AT SOUTHERN METHODIST UNIVERSITY

At its meeting held on May 22, 1929, the Board of Directors authorized the formation of a Student Branch at the Southern Methodist University, Dallas, Texas. The branch has organized and selected the officers named below:

Willard Cox, Chairman
J. V. Melton, Vice-Chairman
Porter Lindsley, Jr., Secretary-Treasurer

Dean E. H. Flath has been appointed Counselor of the Branch.

PAST BRANCH MEETINGS

Alabama Polytechnic Institute

First meeting of the season. Professor Hill, Counselor of the Branch, discussed the plans for the convention to be held in November. Several announcements of local interest were made. September 26. Attendance 20.

University of Arizona

Professor J. C. Clark, Counselor and Barney Shehane, Chairman of the Branch, gave reports of the Pacific Coast Convention. September 20. Attendance 10.

Barney Shehane and Otto Mangum presented papers on Summer experiences with the New State Electric Co. and the Miami Copper Co. September 27. Attendance 12.

Bucknell University

E. C. Metcalf read a paper on *Automatic Railway Substations* which was illustrated. Discussion followed. October 7. Attendance 22.

University of California

As this meeting was in the form of a banquet there was no executive business discussed. Three papers were presented: *The Engineer of Tomorrow*, by V. T. Johnson, Student; *Why I Took Up Engineering*, by Norman H. Adams, Student; *Design of Automatic Substations*, by R. B. Kellogg, Pacific Gas & Electric Co. A brief description of the Pacific Coast Convention was given by F. R. Norton. September 13. Attendance 70.

Executive Business. Two papers presented: *Descriptions of Sound Motion Pictures*, by Frank R. Norton; *Description of an Electrical System of Television*, by H. R. Lubcke, Television Engineer. Refreshments served. September 25. Attendance 45.

Carnegie Institute of Technology

Professors W. R. Work and B. C. Dennison spoke on the benefits of Student enrolment and also membership in the National organization. October 1. Attendance 64.

Clarkson College

Reports of various committees presented. Professor A. R. Powers, Counselor of the Branch, gave a talk on the plans for the coming season. Coffee and cake served after the meeting. October 8. Attendance 20.

Clemson Agricultural College

Two papers presented as follows: *The Making of an Engineer*, by G. W. Sackman, Student; and *Psychology of Getting On*, by W. C. Snyder, Student. Luncheon served after meeting. October 3. Attendance 38.

University of Denver

A discussion took place as to the best method of obtaining the interest of non-members. Plans for the coming membership campaign were discussed. September 30. Attendance 7.

University of Detroit

Talk on "Things We Don't Think About," by Raymond J. Abele. Two reels of moving pictures presented on "Hydro-Electric Power Production in the New South." Short talks by new officers and some of the faculty members. October 9. Attendance 32.

Election of officers: Wm. F. Haldeman, Chairman; R. J. Abele, Vice-Chairman; W. R. Moyers, Secretary; R. L. Sailer, Treasurer. September 10.

University of Idaho

The meeting was held for the purpose of organizing the year's work. Talk by Professor J. H. Johnson, Counselor of the Branch, on the benefits of the Institute. October 1. Attendance 34.

Lafayette College

Election of officers as follows: Earl C. Albert, Chairman; Murray G. Clay, Vice-Chairman; William F. Titus, Secretary-Treasurer. September 29.

Lewis Institute

Election of officers as follows: G. W. Malstrom, Chairman; E. R. Borden, Secretary. October 2. Attendance 13.

Mississippi A. & M. College

Election of officers. Professor L. L. Patterson, Counselor, gave a talk on the advantage of Student membership. October 3. Attendance 21.

Montana State College

Papers presented by Messrs. Murray Davidson and Eitaro Etow. Discussion followed regarding the electrical show which was to be held on October 21. October 9. Attendance 56.

University of Nebraska

Student talks given by R. R. Dysart, F. V. Peterson and B. R. Robinson on their experiences during the past summer. Chairman Schneider made a few explanatory remarks regarding the benefits of Student enrolment. October 9. Attendance 48.

The Newark College of Engineering

Committee members appointed. Three propositions were explained concerning a proposed change in the By-laws for the transfer from Student to Associate membership. October 7. Attendance 31.

The College of the City of New York

Election of officers as follows: Robert Fassnacht, Chairman; Frank J. Wodicka, Secretary. September 26. Attendance 15.

University of North Dakota

Talk by Professor H. F. Rice, Counselor, on the benefits of the A. I. E. E. A still film on "Train Radio" was shown. Doughnuts and cider served. October 3. Attendance 19.

University of Notre Dame

Professor J. A. Caparo, Counselor, reviewed the past success of the Branch and urged future publicity. Smokes and refreshments served. September 23. Attendance 60.

Ohio Northern University

President McGahan welcomed new Students. Professor Campbell, Counselor, discussed the value of membership in the A. I. E. E. Dean Needy, Head of the Engg. Dept. gave illustrations explaining the great engineering age we are living in. Smokes and refreshments served. September 26. Attendance 57.

Oklahoma A. & M. College

Professor Naeter, Head of the Elec. Engg. Dept., presented a paper on *The Use of the Pendulum in the Measurement of Electrical Energy*. September 22. Attendance 18.

University of Oklahoma

Professor F. G. Tappan, Counselor, gave a discussion on Light's Golden Jubilee and the banquet which will be held on October 21. This Branch is providing several attractions for the banquet, the most notable being the so-called "talking electric sign." This sign was designed and built by the Branch. Discussion followed concerning the advantages of Institute membership and the relation of the University of Oklahoma Branch to the Oklahoma City Section. Refreshments served. October 16. Attendance 50.

University of Pittsburgh

Talk by Professor H. E. Dyche, Counselor. October 26. Attendance 42.

Talk by E. S. McClelland on "History of the Westinghouse Elec. & Mfg. Co." October 3. Attendance 81.

Rensselaer Polytechnic Institute

Committee appointments. Several Students gave talks on their work during the past summer. October 8. Attendance 75.

Rhode Island State College

Talks as follows: "History of Radio," by George E. Arnold, Student. "Recent Developments," by Charles Pagella, Student. October 9. Attendance 17.

Rose Polytechnic Institut

Election of officers as follows: D. E. Henderson, Chairman; J. H. Corp, Secretary; C. A. Lotze and E. A. Johnson members Program Committee. September 27. Attendance 15.

J. H. Corp reviewed the By-laws relating to Student enrolment. D. E. Henderson gave a talk on the meeting to be held in Chicago in December. Professor C. C. Knipmeyer spoke about the Branch and gave suggestions as to how meetings should be conducted in the future. October 2. Attendance 34.

University of South Carolina

First meeting of the season. Voted to hold three meetings each month. Election of Executive Committee members. October 4. Attendance 14.

Three papers presented by students, *Short Transmission Lines*, by J. D. Bell; *Sketch on Aeronautics*, by H. W. Farnam; *Development of Communication*, by C. A. Riley. October 11. Attendance 26.

South Dakota School of Mines

Professor J. O. Kammerman, Counselor, gave a talk on the activities of the Institute. Professor E. E. Clark spoke about his summer travels. October 3. Attendance 28.

University of Southern California

N. B. Hinson, Chairman of the Los Angeles Section, spoke regarding the By-laws concerning Student enrolment. He also spoke on the industrial development of Southern California. September 25. Attendance 50.

Syracuse University

Election of officers as follows: D. A. MacGregor, Chairman; M. J. Wright, Secretary. October 9. Attendance 10.

University of Tennessee

Discussion of plans for future meetings. October 11. Attendance 16.

Texas A. & M. College

Discussion of general Branch activities. September 27. Attendance 34.

University of Utah

Plans for the year were discussed. Counselor J. H. Hamilton spoke on the advantages of being an enrolled Student. A film showing the building of the Panama Canal was shown. October 8. Attendance 20.

Virginia Military Institute

Committee appointed to draw up new set of By-laws. Papers presented by students: *Application of Electricity to Modern Transportation*, by J. T. Brodnax; *The Benefits Derived from the A. I. E. E.*, by H. B. Blackwood; *Why Brookland Adopted the Low Voltage A. C. Network*, by A. F. Black. September 27. Attendance 43.

Virginia Polytechnic Institute

Appointment of Executive Committee. Discussion of coming student convention in Charlottesville. Talk on Branch activities by Professor Cladius Lee, Counselor. October 2. Attendance 22.

West Virginia University

Election of officers as follows: C. E. Moyers, President, G. H. Hollis, Secretary; E. M. Hansford, Treasurer. September 23. Attendance 38.

Student papers presented as follows: *The Diesel Aircraft Motor*, by W. S. McDaniels; *Arc Welding in the Shops of the Northern Pacific Ry. Co.*, by A. F. Fervier; *Recent Developments in Telephone Construction Practises*, by G. H. Hollis; *The Reason for and Meaning of S. A. E. Viscosity Number*, by W. H. Rose; *Hydrogen—The Successor to Air*, by E. M. Hansford; *The Roof Steam Accumulator*, by G. S. Garrett; *Economics of Distribution Systems*, by G. C. Barnes. September 30. Attendance 38.

A film on Electrical Measuring Instruments was presented. October 7. Attendance 40.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these Founder Societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES, SEPTEMBER 1-30, 1929

Unless otherwise specified, books in this list have been presented by the publishers. The Societies do not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

ANALYSE DILATOMETRIQUE DES MATERIAUX.

By Pierre Chevenard. Paris, Dunod, 1929. 90 pp., illus., diagrs., 11 x 9 in., paper. 25,50 fr.

Professor Chevenard discusses the value of the dilatometric method in the study of thermal changes in metals, describes the apparatus and methods that he has evolved at the Imphy steel-works, and gives some of the interesting results that he has obtained in studying the quenching of aluminum bronze, the graphitization of cast iron, the firing of refractories, and other industrial processes.

APPLIED GEOPHYSICS IN THE SEARCH FOR MINERALS.

By A. S. Eve and D. A. Keys. Cambridge, Eng., University Press; N. Y., Macmillan Co., 1929. 253 pp., illus., diagrs., 9 x 6 in., cloth. $4.50.

A review of the various methods—magnetic, electrical, gravitational, seismic, etc.—that have been proposed for geological exploration and prospecting. The authors discuss both the theoretical and practical sides of the schemes of exploration now available, in the light of varied personal experience in the field.

BARRAGES CONJUGUES ET BASSINS DE COMPENSATION.

By Georges Laporte. Paris, Dunod, 1929. 116 pp., diagrs., 10 x 7 in., paper. 35,50 fr.

Discusses the effect upon each other of two neighboring power developments upon the same river. The author treats of the equipment appropriate in these circumstances, the rules for using the water that become necessary, and the reserves and compensating reservoirs required to maintain a flow in the river which will satisfy the owners of its banks. The discussion is illustrated by concrete examples taken from the author's practical experience.

DIE DAUERPRUFUNG DER WERKSTOFFE.

By O. Föppl, E. Becker and G. v. Heydekampf. Berlin, Julius Springer, 1929. 124 pp., illus., diagrs., 10 x 7 in., paper. 9,50 r. m.

A discussion of apparatus and methods for determining the fatigue of metals subjected to vibration. A variety of testing machines is described, their uses explained and methods of testing given, together with some results.

FESTSCHRIFT PROF. DR. A. STODOLA.

Edited by E. Honegger. Zürich u. Lpz., Orell Füsseli Verlag, 1929. 602 pp., illus., diagrs., port., 10 x 7 in., paper. 24.-r. m.

Professor Stodola's friends and former pupils have commemorated his seventieth birthday and approaching retirement by issuing this handsome volume. It contains, in addition to a biographical sketch of Stodola and a bibliography of his writings, sixty-three papers by eminent engineers and scientists, upon various problems of engineering and physics, particularly of the steam turbine. The list of contributors is an imposing one.

FIELD ENGINEERING.

By William H. Searles. 20th edition revised and enlarged by H. C. Ives. N. Y., John Wiley & Sons, 1929. 2 v. in 1, diagrs., tables, 7 x 4 in., fabrikoid. $4.00.

The first volume of the new edition of this well-known manual differs from the last edition chiefly by the addition of a concise chapter on highway curves, which makes the book useful to highway engineers, as well as railroad engineers. The second volume has many changes and additions. Seven-place tables of the natural trigonometric functions replace the former five-figure tables. Tables of natural secants and cosecants have been added. The table of trigonometric formulas has been rearranged and extended.

HANDBOOK OF FORMULAS AND TABLES FOR ENGINEERS.

By Clarence A. Peirce, Walter B. Carver and Charles E. O'Rourke. 3rd edition. N. Y., McGraw-Hill Book Co., 1929. 228 pp., 8 x 5 in., fabrikoid. $2.50.

The aim of the compilers has been to produce a small book, of really convenient size for the pocket, containing the most useful tables and formulas. In this edition, some of the more essential civil engineering data have been added, enlarging the field of usefulness of the book. Several sections have also been enlarged and revised.

HYDRAULIC LABORATORY PRACTICE; trans. revised to 1929, of Die Wasserbaulaboratorien Europas, by V. D. I. Edited by John R. Freeman. N. Y., American Society of Mechanical Engineers, 1929. 868 pp., illus., 12 x 9 in., cloth. $10.00.

Some years ago Dr. John R. Freeman urged the German Society of Engineers to publish a volume describing the hydraulic laboratories of Europe and the principal research work of each of them. The result of this suggestion was "Die Wasserbaulaboratorien Europas," which appeared in 1926, and which now appears in English under Dr. Freeman's editorship.

The English edition will be of interest to every hydraulic engineer. To the professor of hydraulics it affords descriptions of the important laboratories of the world, of their equipment, organization, management, and of the work which they have carried out. The engineer in practice will find many helpful data in the text and in the numerous bibliographies. No such general survey of experimental activities in this science has hitherto existed.

The translation contains much more material than the original. Appendixes describing other European laboratories, and some American ones, have been added. Biographies of the directors of the various laboratories have been inserted, as well as several monographs on important general subjects.

MOTOR VEHICLES AND TRACTORS.

By P. M. Heldt. Nyack, N. Y., P. M. Heldt, 1929. 678 pp., illus., diagrs., tables, 9 x 6 in., cloth. $8.00.

A textbook on design, covering all the elements of the automobile and tractor except the engine and electrical equipment. The book is intended to replace the former second volume of the author's "Gasoline Automobile" and repeats some of that material, but is principally a new work. The book is suited for class or home study; uses only simple mathematics and has much practical information.

RADIOTECHNIK, VI; Die Elektrischen Wellen.

By F. Kiebitz. Ber. u. Lpz., Walter de Gruyter & Co., 1929. 125 pp., diagrs., 6 x 4 in., cloth. 1,50 r. m.

A brief text on Herzian waves, especially the waves used in radio. Their characteristics, radiation and reception, diffusion and directing are discussed with a minimum of mathematics. A simple introduction to the subject for students and operators of radio telegraphy.

RELAIS UND SCHUTZSCHALTUNGEN IN ELEKTRISCHEN KRAFTWERKEN UND NETZEN.

Edited by Reinhold Rüdenberg. Berlin, Julius Springer, 1929. 281 pp., illus., diagrs., tables, 9 x 6 in., bound. 25,50 r. m.

Contains a course of lectures upon protective relays given at Berlin during 1927 and 1928 by seven prominent engineers, under the auspices of the Electrical Engineering Society and the Technical High School. Discusses the importance of relays as safety devices, the failures that occur in networks and the principles of protection; the basic principles of relay action and construction, current relay construction, use and testing, the protection of generating and transmission equipment, and bases for further developments.

RENFORCEMENT DES SOUDURES, COUVRE-JOINTS DISCONTINUS SOUDES.

By E. Hoehn. Paris et Liège, Ch. Béranger, 1929. 103 pp., diagrs., tables, 9 x 6 in., paper. 20.-fr.

A study of the value of welded buttstraps as a reinforcement of welded joints in boilers and other pressure vessels. The results of tests are given and the distribution of stresses discussed. Data are given for use by designers.

SIMPLIFICATION OF HIGHWAY TRAFFIC.

By William Phelps Eno. Saugatuck, Conn., Eno Foundation for Highway Traffic Regulation, Inc., 1929. 206 pp., illus., diagrs., 9 x 7 in., cloth. $5.00; paper, $3.00.

Mr. Eno has devoted his life to the study of highway traffic regulation. In the present book, which is to a certain extent a revision and rearrangement of material selected from his former books, he discusses particularly the selection and use of traffic guides, systems of regulation, methods of accelerating traffic and increasing safety. Many practical questions are handled on the basis of wide experience. Professor C. J. Tilden has prepared an appendix giving an account of Mr. Eno's activities and of the development of traffic regulation since they began.

STEAM AND GAS ENGINEERING.

By Thomas E. Butterfield. N. Y., D. Van Nostrand Co., 1929. 481 pp., illus., diagrs., tables, 9 x 6 in., cloth. $4.50.

An introductory text for engineers by the Professor of Heat Power Engineering at Lehigh University. The entire field of power production from steam and gas is covered, with emphasis upon the natural laws involved and upon the various kinds of apparatus used to apply them in practise. Several chapters are devoted to descriptions of engines, boilers, gas producers and other apparatus. Many problems are given.

UBERTRAGUNGSTECHNIK.

By Rudolf Winzheimer. Mün. u. Ber., R. Oldenbourg, 1929. 233 pp., illus., diagrs., 9 x 6 in., cloth. 12.-r. m.

A text-book presenting the general principles of the electrical transmission of speech, either by telephone or radio, and intended for students of these subjects. The book first discusses the electrical and acoustical principles involved in telephony, the theory of telephone lines, amplifiers, networks and telephone cables. The specific variations of radio transmission are then discussed. A basic knowledge of electrical transmission theory is assumed.

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contribution from the societies and their individual members who are directly benefited.

Offices:—31 West 39th St., New York, N. Y.,—W. V. Brown, Manager.
1216 Engineering Bldg., 205 W. Wacker Drive, Chicago, Ill., A. K. Krauser, Manager.
57 Post St., San Francisco, Calif., N. D. Cook, Manager.

MEN AVAILABLE.—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to ***EMPLOYMENT SERVICE, 31 WEST 39th Street, New York City,*** *and should be received prior to the 15th day of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary: temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

POSITIONS OPEN

ELECTRICAL ENGINEER, Canadian, college graduate, 25-28. Power transmission, line construction experience desirable. Work of general nature at Canadian plant of electrical manufacturer. May lead to sales engineering work. Apply by letter giving full information. X-9594.

ELECTRICAL ENGINEER, thoroughly familiar with the requirements of the paper mill industry. Must be able to design, layout, install and supervise entire electrical system, wiring, apparatus and equipment pertinent to construction and operation of modern paper mills. Apply by letter giving full information, such as age, technical training, previous experience, present salary, references, etc. Location, South. X-9625-CS.

VACUUM TUBE ENGINEER, familiar with tube measurement work, quality control of tubes, and the tube side of circuit work. Apply by letter. Location, New Jersey. X-9671-C.

LOUD SPEAKER ENGINEER, capable of doing development work on speakers and making speaker performance measurements. Apply by letter only. Location, New Jersey. X-9672-C.

ENGINEER, with engineering and test experience in paper condenser work. Apply only by letter. Location, New Jersey. X-9673-C.

SWITCHBOARD ENGINEER, capable of laying out small switchboards for controlling battery charging motor generator sets, small alternators, etc. Man with two or three years' experience testing or designing preferred. Must be technical school or college graduate. Apply by letter stating training, experience, and salary desired. Location, New York State. X-9679-C.

TRANSFORMER ENGINEER, with two or three years' experience in testing or designing transformers. Must be technical school or college graduate. Apply by letter stating training, experience, and salary desired. Location, New York State. X-9680-C.

RECENT GRADUATE ELECTRICAL ENGINEER, for research work. Apply by letter. Salary $30 a week. Location, New England. X-8464.

ELECTRICAL ENGINEER, preferably with postgraduate schooling in the electrical branches of physics and a few years' experience in industrial research or development, for development and research work with a growing firm in varied fields embracing control apparatus and vacuum-tube applications. Apply by letter. Location, New England. X-9387.

ELECTRICAL ENGINEER, experienced in the manufacture of vacuum tubes for radio work. Apply by letter. Location, New Jersey. X-9067.

SALES ENGINEER, 1927-1928, graduate in electrical engineering, for commercial side of a

manufacturing organization; traveling sales work. Opportunity. Apply by letter. Location, Middle West. X-7662-C.

RECENT GRADUATE, electrical engineer, willing to locate in eastern territory near Philadelphia, and to enter traveling sales work, handling a-c. motors and fans. Must have clean-cut personality. Apply by letter. Headquarters, Middle West. X-3172-C.

MEN AVAILABLE

ELECTRICAL ENGINEER, 34, single; 11 years' experience in development, application, and testing of railway and industrial control equipments including five years heavy traction work. Available upon one month's notice. Location, immaterial. C-6506.

ELECTRICAL ENGINEER, 28, single, B. S., 1929, graduated with high honors, desires connection with manufacturer of electrical machinery or utility company. Preferably production, management, or design. Opportunity for advancement considered most important. Two years' test floor experience. Location, Eastern States or abroad. Excellent knowledge of Russian. Available on short notice. C-6526.

ELECTRICAL ENGINEER, with seven years' experience in the electrical field including: telephone work, developments in instruments and measuring methods; also meter, protection and apparatus testing in the field. Desires position here or abroad. Available January, 1930. C-3911.

SALES ENGINEER, 28, single, M. I. T., 1925, B. S. in E. E. degree. One year electric locomotive and transmission design. One year assembly and test work with large electrical company. Two years industrial and utility sales engineer. Desires sales engineer position requiring technical background with a concern affording good opportunity. Located at present in New York. C-1415.

ELECTRICAL ENGINEER, 30, single, college graduate, London. General Electric Co. and British Thomson Houston Co. Test courses. Seven years' experience in Australia and the United States of America, on hydroelectric and steam power plants, transmission lines, and substations. Location optional. Short notice. References. C-6518.

POWER OR MECHANICAL SUPERINTENDENT, 41, experienced steam, gas, air, hydraulic, electric power plant construction and operation; institutional, industrial, and building mechanical design and maintenance. Now employed. Middle Northwest. Desires good industrial connection, 30 days' notice. Specialty, straightening out, revamping and coordinating power services. C-987.

ELECTRICAL ENGINEER, single, 38, desires position in engineering or sales department. Seven years' experience with one small company manufacturing standard and special rotating machinery, d-c. and a-c. ratings up to 500 kw. or hp. Was successively in charge of testing, service, engineering, correspondence and sales. Location, immaterial. C-6543.

ELECTRICAL ENGINEER, twelve years' experience electrical design of power houses, substations, transmission lines, industrial plants, in all branches and details of work. Also eight years' other electrical, mechanical engineering experience including power plant testing, machinery design. E. E. degree. Age 43, location, vicinity New York City. Available at once. C-6542.

ELECTRICAL ENGINEER, university graduate, seven years' experience on transmission and distribution planning, design of transmission lines and substations, construction, operation. Utility cadet course. Speaks foreign languages. Desires position with utility, export firm or consulting engineers. Now employed. Europe or South America considered. B-8043.

GRADUATE ELECTRICAL ENGINEER, E. E., wide experience in construction, operation, maintenance, generating, transmission at 100,000 volts, underground transmission, 6600 and 22,000 volts, outdoor and indoor substations, mill installations. Has sales and managing experience, Latin, America, and India. Speaks English, Spanish, German, French, and Hindustani. Location, immaterial. Now employed. C-4222.

ELECTRICAL ENGINEER, 27, married, five years' experience in powerhouse and substation construction, operating, general maintenance, specializing in relay and meter work. Desires position abroad. C-6548.

HYDROELECTRIC ENGINEER, 37, estimating engineer for the Big Creek Project, desires connection for field work on budgets, estimates, appraisals or cost accounting. Has the basic construction experience in generation and distribution necessary for such analyses. B. S. in E. E. from the California Institute of Technology. C-6498.

ENGINEER, ELECTRICAL-MECHANICAL age, 41; married, speaks Portuguese and Spanish; with 25 years' experience on construction and maintenance of steam, hydroelectric, and electrical plants, seeks a situation on the construction, or maintenance of a power station, mine or industrial plant abroad. C-6553.

JUNIOR ELECTRICAL ENGINEERING GRADUATE, 1928. Desires position with private professional concern doing consulting and construction engineering. Four years practical experience, energetic, ambitious, and willing to work hard. C-6446.

ELECTRICAL ENGINEERING GRADUATE with two years' experience in construction and maintenance of electric locomotives and multiple-unit cars, both a-c. and d-c. Desires position in electric railway or subway construction or operation. C-6513.

GRADUATE ELECTRICAL ENGINEER, 28, married, nine years' experience engineering, construction and operation of underground and overhead transmission and distribution systems. Last three years as division engineer for large metropolitan utility. Desires position in engineering or construction division of a large holding company or industry. Location immaterial. B-9408.

PERSONNEL IMPROVEMENT SYSTEM, new and original application of natural laws develop, multiply and indicate the constinctive efforts of ambitious employees and likewise minimize negative influence. This system is available to organization heads and will be developed to fit your specific application without any interference, by an engineer of wide experience. C-1867.

ELECTRICAL ENGINEER, age 29, five years' varied experience; test floor, application, design, construction and maintenance. Now in charge of electrical department for mining company. Desires position as assistant plant engineer or assistant electrical engineer with large industrial plant. Good personality and very well recommended. B-9001.

ELECTRICAL ENGINEER, 33, married, now located Western New York, seven years sales engineering, two years instructor, two years distribution and central station drafting. Able to design and sell induction motors. Available on 30-day notice. B-3853.

MEMBERSHIP—Applications, Elections, Transfers, Etc.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before November 30, 1929.

Andersson, A., General Electric Co., Pittsfield, Mass.
Ando, K., Texas Power & Light Co., Dallas, Tex.
Barcus, E. D., Southern California Telephone Co., Los Angeles, Calif.
Barter, P. A., Buchans Mining Co., Ltd., Buchans, Newfoundland
Bathe, C. E., Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Beck, L. E., Purdue University, W. Lafayette, Ind.
Brown, C. J., Samson Electric Co., New York, N. Y.
Buitrago, E. J., Jr., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Burkholder, J. C., (Member), Canadian National Telegraphs, Toronto, Ont., Can.
Carey, P. C., (Member), Runyon & Carey, Newark, N. J.
Carter, H. B., General Electric Co., Fort Wayne, Ind.
Chase, D. D., General Electric Co., Schenectady, N. Y.
Coldwell, K. I., Texas Creosoting Co., Orange, Tex.
Creedy, F., (Member), Lehigh University, Bethlehem, Pa.
Danner, R. F., Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Davis, C., Michigan Bell Telephone Co., Detroit, Mich.
Davis, F. F., International Tel. & Tel. Co., New York, N. Y.
Driscoll, J. E., Western Mass. Co., Springfield, Mass.
Eppard, C. M., Union Electric Light & Power Co., St. Louis, Mo.
Falkenberg, R. T., Westinghouse Elec. & Mfg. Co., Houston, Tex.
Ferris, F. S., 649 S. Main St., Akron, Ohio
Hague, B., (Member), Brooklyn Polytechnic Institute, Brooklyn, N. Y.
Haycock, O. C., University of Utah, Salt Lake City, Utah
Hemphill, L. F., General Electric Co., Fort Wayne, Ind.
Hendeberg, H., Sargent & Lundy, Chicago, Ill.
Hessler, V. P., Iowa State College, Ames, Iowa
High, T. L., Pacific Electric Mfg. Corp., Portland, Ore.
Hudson, A. R., Board of Education, Louisville, Ky.
Johannsen, E., Pacific Electric Mfg. Co., San Francisco, Calif.
Jones, E. C., West Virginia University, Morgantown, W. Va.
Jones, J. L., Kentucky Electric Development Co., Louisville, Ky.
Katz, L. S., Grove Hall Radio Co., Roxbury, Mass.
Lukens, A. F., General Electric Co., Pittsfield, Mass.
Malley, R. D., (Fellow), Cooper Hewitt Electric Co., Hoboken, N. J.
McLean, C., Northwestern Electric Co., Portland, Ore.
McQuillen, J. V., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
McRae, H. T., New Jersey Bell Telephone Co., Newark, N. J.
Moreno, Y. G., Border Telephone & Light Co., Tijuana, B. Cal., Mexico

Mullowney, T. F., New York Telephone Co., New York, N. Y.
Murphy, L. K., Brooklyn Edison Co., Inc., Brooklyn, N. Y.
Nicolaisen, R. J., Gibbs & Hill, New York, N. Y.
Odarenko, T. M., New York Telephone Co., New York, N. Y.
Oldenburg, P. R., Duquesne Light Co., Pittsburgh, Pa.
Parker, L. F., British Columbia Electric Railway Co., Vancouver, B. C., Can.
Petersen, F. C., New York Edison Co., New York, N. Y.
Pirkey, J. W., (Member), Arcturus Radio Tube Co., Newark, N. J.
Prince, R. W., (Member), Chesapeake & Potomac Telephone Co., Washington, D. C.
Pringle, W. A., General Electric Co., Fort Wayne, Ind.
Rankin, L. R., Carnegie Steel Co., Farrell, Pa.
Rhael, R. J., Bell Telephone Laboratories, Inc., New York, N. Y.
Roloson, G. B., (Member), California School of Mechanical Arts, San Francisco, Calif.
Rose, H. B., 55 Hanson Place, Brooklyn, N. Y.
Rudolph, W. J., (Member), Electrical Testing Laboratories, New York, N. Y.
Russell, C., Jr., University of New Mexico, Albuquerque, N. M.
Shoch, W. N., Philadelphia Electric Co., Philadelphia, Pa.
Shoffner, J. R., Markle-Bullers Coal Co., Inc., Dora, Pa.; C. E. Ringgold Coal Co., Inc.; C. E. Katukas Coal Co., Inc., Timblin, Pa.
Skonberg, E. A., (Member), Electric Motor Repair Co., Springfield, Mass.
Smith, E. A. H., New Jersey Bell Telephone Co., Newark, N. J.
Snow, B. H., "Electrical West," Portland, Ore.
Stanton, J. M., Electrical Research Products, Inc., Seattle, Wash.
Stickley, G. W., Aluminum Co. of America, Massena, N. Y.
Taylor, J. A., Tallassee Power Co., Badin, N. C.
Tiedemann, D. P., Purdue University, Lafayette, Ind.
Tiernan, T. F., National District Telegraph Co.; New York, N. Y.
Underhill, J. E., British Columbia Electric Railway Co., Ltd., Vancouver, B. C., Can.
Watchorn, C. W., Pennsylvania Water & Power Co., Baltimore, Md.
Wilhelm, H. T., Bell Telephone Laboratories, Inc., New York, N. Y.
Young, R. C., Kuhlman Electric Co., Bay City, Mich.
Total 68

Foreign

Bateman, W. T., (Member), Ferguson, Pallin Ltd., Manchester, England
Burton, W., Shropshire, Worcestershire & Staffordshire Electric Power Co., Halesowen, Eng.
Dean, G. H., (Member), Allen West & Electric Control, Ltd., Brighton, Sussex, Eng.
Edmondson, F. C., (Member), City of Perth Electricity & Gas Dept., Perth, Western Australia
Phatak, R. K., Tata Hydro-Electric Supply Co., Bombay, India
Total 5

STUDENTS ENROLLED

Brown, George H., University of Wisconsin
Burnett, Carlos E., Southern Methodist University
Bush, Arthur E., University of Detroit
Byrne, Howard E., University of Detroit
Cox, Willard J., Southern Methodist University
Frauman, Issie, Southern Methodist University
Griffith, Arthur F., Lehigh University
Griffith, David P., Lehigh University
Headley, Francis B., University of Nevada
Johnson, Henry W., Drexel Institute
Krumm, Harold F., Engineering School of Milwaukee
Larose, Victor A., Engineering School of Milwaukee
Lindsley, Robert P. Jr., Southern Methodist University
Lyon, Stern A., Northeastern University
Melton, J. V., Southern Methodist University
Nash, Floyd M., University of California
O'Donnell, James T., Northeastern University
Robertson, George M., University of Southern Calif.
Rogers, James H., Southern Methodist University
Rosen, Sidney, University of Southern California
Rotter, Cyril F., Engineering School of Milwaukee
Sailer, Roman L., University of Detroit
Santos, Bartolome, University of Detroit
Schley, Woodruff H., Southern Methodist University
Sinclair, Donald B., Mass. Institute of Technology
Stortz, Frank A. Jr., University of New Mexico
Swart, Berry G., Michigan College of Mining & Technology
Talbot, Thomas, Southern Methodist University
Taylor, Wesley, D., University of Minnesota
Tsang, Isaac H., Engineering School of Milwaukee
Tucker, D. J., Southern Methodist University
Total 31

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F. W. Willis, Tata Power Company, Bombay House, Bombay, India.
Guido Semenza, 39 Via Monte Napaleone, Milan, Italy.
P. H. Powell, Canterbury College, Christchurch, New Zealand.
M. Chatelain, Lesnoi Polytechnic Institute, Apt. 27, Leningrad, U. S. S. R.
Axel F. Enstrom, 24a Grefturegatan, Stockholm, Sweden.
W. Eidson-Dew, P. O. Box 4563 Johannesburg, Transvaal, Africa.

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(A list of the personnel of Institute committees may be found in the September issue of the Journal.)

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Transportation, Sidney Withington

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(The Institute is represented on the following bodies; the names of the representatives may be found in the September issue of the Journal.)

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American Bureau of Welding
American Committee on Electrolysis
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National Safety Council, Electrical Committee of A. S. S. E.—Engineering Section
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U. S. National Committee of the International Electrotechnical Commission
Washington Award, Commission of

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Saskatchewan	(10)	J. R. Crowley	A. B. Coward, Light & Power Dept., Regina, Sask., Canada
Schenectady	(1)	R. Treat	B. E. Johnson, Rm. 435, Bldg. 2, General Electric Co., Schenectady, N. Y.
Seattle	(9)	L. N. Robinson	George S. Smith, Elec. Engg. Dept., University of Washington, Seattle, Wash.
Sharon	(2)	J. B. Gibbs	S. S. Cook, Westinghouse E. & M. Co., Sharon, Pa.
Southern Virginia	(4)	H. C. Leonard	Cecil Gray, Westinghouse E. & M. Co., 912 Electric Bldg., Richmond, Va.
Spokane	(9)	Earl Baughn	Loren A. Traub, 215 Symons Bldg., Spokane, Wash.
Springfield, Mass.	(1)	Fred L. Hunt	B. V. K. French, American Bosch Magneto Corp., Springfield, Mass.
Syracuse	(1)		F. E. Verdin, 1206 Hills Bldg., Syracuse, N. Y.
Toledo	(2)	E. B. Featherstone	Max Neuber, 1257 Fernwood Ave., Toledo, O.
Toronto	(10)	F. F. Ambuhl	W. F. Sutherland, Toronto Hydroelec. Sys., 225 Yonge St., Toronto, Ont., Canada
Urbana	(5)	M. A. Faucett	C. E. Skroder, Univ. of Ill., Urbana, Ill.
Utah	(9)	A. C. Kelm	L. B. Fuller, Utah Pr. & Lt. Co., Salt Lake City, Utah
Vancouver	(10)	J. Teasdale	D. Robertson, Canadian Gen. Elec. Co., Ltd., Vancouver, B. C., Canada
Washington	(2)	W. A. E. Doying	G. L. Weller, Chesapeake & Potomac Tel. Co. & Assoc. Cos., 725-13th St., N. W., Washington, D. C.
Worcester	(1)	H. H. Newell	R. P. Bullen, General Elec. Co., 704 State Mutual Bldg., Worcester, Mass.
Total 57			

LIST OF BRANCHES

Name and Location	District	Chairman	Secretary	Counselor (Member of Faculty)
Akron, Municipal Univ. of, Akron, Ohio	(2)	Glenn O. Hite	G. G. Clark	J. T. Walther
Alabama Polytechnic Inst., Auburn, Ala.	(4)	T. S. Winter	O. T. Allen	W. W. Hill
Alabama, Univ. of, University, Ala.	(4)			
Arizona, Univ. of, Tucson, Ariz.	(8)	Barney Shehane	F. F. Denney	J. C. Clark
Arkansas, Univ. of, Fayetteville, Ark.	(7)	D. J. Morrison		W. B. Stelzner
Armour Inst. of Tech., 3300 Federal St., Chicago, Ill.	(5)	J. Dollenmaier	S. Janiszewski	E. H. Freeman
Brooklyn Poly. Inst., 99 Livingston St., Brooklyn, N. Y.	(3)	F. J. Mullen	R. G. O'Sullivan	Clyde C. Whipple
Bucknell University, Lewisburg, Pa.	(2)	E. C. Metcalf	R. G. Tingle	W. K. Rhodes
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Ball Bearings.—"The Gurney Ball Bearing Manual," 202 pp. A comprehensive treatment of the subject describing numerous types of bearings and their proper applications. Prices are included. Marlin-Rockwell Corporation, Jamestown, N. Y.

Silver Solder.—Bulletin, 20 pp., on "The Proper Selection and Use of Silver Solder." According to the manufacturer there are many uses of silver solder in electrical manufacturing, and silver compositions that have been especially developed and perfected for the electrical industry are described in the bulletin. Handy & Harman, 57 William Street, New York.

NOTES OF THE INDUSTRY

Champion Switch Company Appointments.—R. J. Stewart, formerly with the West Penn Power Company, is now head of the inspection department, and J. A. Dudley, formerly of the Chrysler Corporation, has been appointed to take charge of production for the Champion Switch Company, Kenova, West Virginia.

The Wagner Electric Manufacturing Corporation, St. Louis, announces the removal of two branch sales offices. The Milwaukee sales office and service station has been moved from 501 Broadway to 525-27 Broadway. The St. Louis sales office has been removed from 505 Shell Building to 909 Plaza Olive Building. Those removals were necessitated by the increased business requiring more space.

Increased Orders for G-E.—Orders received by the General Electric Company for the three months ended September 30th amounted to $116,688,014, compared with $90,328,666 for the corresponding quarter of 1928, an increase of 29 per cent, President Gerard Swope has announced. For the nine months ended September 30th orders received amounted to $337,404,470, compared with $260,686,463 for the first nine months of last year, also an increase of 29 per cent.

A New Oil Purifier.—The largest portable combination centrifuge and filter press on the market is now being offered through the Westinghouse Electric and Manufacturing Company. It is the Sharples combination portable super-centrifuge and filter press, and is made by the Sharples Specialty Company. A Sharples super-centrifuge is combined with Westinghouse filter press equipment and mounted on a truck. The following advantages are claimed for it: Thoroughly cleans 1200 gallons of oil per hour continuously. Purification is complete in one operation. Operation is simple and clean. Practically no oil is lost in handling. Construction is sturdy and simple. Maintenance is remarkably low. Occupies very little floor space—only a space 54 inches by 106 inches. Can be easily moved from place to place.

Great Northern Electrification.—Increased passenger travel following the opening of the Great Northern's 8-mile tunnel under the Cascades is reflected by the purchase from the General Electric Company of four additional 3000-horsepower electric locomotives for use on passenger trains on the electrified division. The new locomotives will cost about $250,000 each. With the completion of the 8-mile Cascade tunnel last January, the railway's entire route through the Cascades was changed from steam to electrical operation. The saving in time afforded by these and other improvements enabled the Great Northern to cut nearly seven hours from the time of its transcontinental trains. The new locomotives will be the same type as those now handling the railway's passenger trains. They weigh approximately 530,000 pounds each and are 75 feet long. They are built so they can be operated in multiples, each unit being capable of handling a 1000-ton train on any of the grades. Each locomotive has six traction motors which deliver power to six axles. The driving wheels are nearly 5 feet in diameter.

New High-Capacity Oil Breakers.—The Pacific Electric Manufacturing Corporation, San Francisco, announces the addition of two more sizes to their "JC" type oil circuit breakers, now available in voltages from 11,000 to 37,000. The JC-17 breaker is rated to interrupt 100,000 kv-a. at 15 kv. and has exceeded this rating in actual test. Types JC-22 and 26 have a rating of 125,000 kv-a. at 25 kv. and 37 kv. respectively. Features of this type of oil circuit breaker include: One cast top member for all three phases, with individual tanks per phase. All operating parts are fastened to the one piece top member and assembled at the factory and shipped without disturbing the factory adjustment. The rotating unit that carries the contacts is composed of Bakelite, insuring positive mechanical strength and a wide safety factor in dielectric strength. Ample oil capacity with high operating speed gives these breakers an interrupting capacity greater than other breakers of comparable size. These breakers may be motor or solenoid operated. Either type of control can be mounted on the end or side of the breaker without the use of additional parts, and the two styles of control are interchangeable as far as mountings are concerned.

Electrical Equipment for Ford.—A turbine generator rated at 110,000 kilowatts, is to be installed by the Ford Motor Company in the power generating station of its River Rouge plant at Fordson, Michigan. This machine, far exceeding the rating of any existing prime mover used for industrial purposes, and involving many novel and unusual features of design, will be used in the manufacture of Ford automobiles. This apparatus, now being built at the Schenectady Works of the General Electric Company, represents interesting departures in design and construction. It is a vertical compound unit and is the first large machine to be made to this design. The high-pressure turbine and generator will be mounted directly on top of the low-pressure turbine and generator, resulting in the most compact unit yet proposed. Each element has a capacity of 55,000 kilowatts. Steam will be used at a pressure of 1200 pounds exclusively. One of the important features of the design—of particular value in the Ford plant, where floor space is at a premium—is the small amount of space which will be taken up by the new unit. The general dimensions include a length of 57 feet 6 inches, a maximum width of 23 feet and a little less than 21 feet overall height from the floor. The approximate weight is 2,000,000 pounds. The space to be occupied is less than a quarter of a cubic foot per kilowatt of output.

The Ford Motor Company has also ordered one 300 hp. and one 300 hp. oil-electric locomotive from the Ingersoll-Rand Company for the River Rouge Plant. These locomotives will be furnished with General Electric equipment and will be built at their Erie Works.

JOURNAL OF THE A. I. E. E.

DEVOTED TO THE ADVANCEMENT OF THE THEORY AND PRACTISE OF ELECTRICAL ENGINEERING AND THE ALLIED ARTS AND SCIENCES

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Vol. XLVIII DECEMBER, 1929 Number 12

A Message From the President.

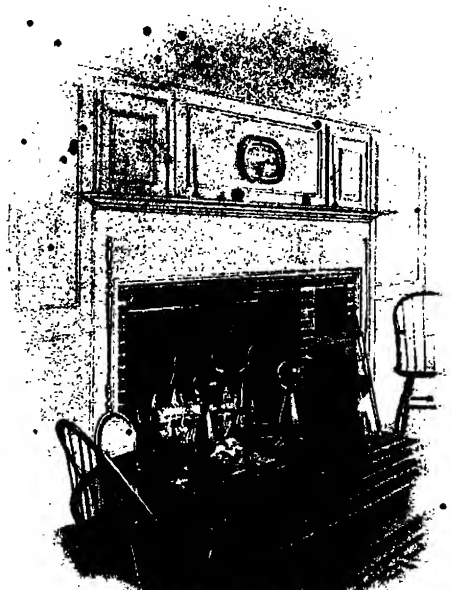
A very Merry Christmas and a Happy New Year to all

FRIENDSHIP AND GOOD WILL

THIS number of the Journal goes to the membership of the Institute with the approach of the Christmas Season and it is appropriate to emphasize the element of friendship and good will always involved in our activities. On behalf of all Institute officers, it is a happy privilege to extend to the entire membership the most cordial of holiday greetings and good wishes for a Merry Christmas and a Happy New Year.

It requires little thought to realize the countless opportunities, in our common work for the Institute, for those who appreciate such friendship and good will. Those who value this feature as among the greatest of their possessions make the most of these opportunities. It is not easy to estimate the loss experienced by those who maintain isolation from these influences. In particular, Section, District, and National Meetings offer personal contact and opportunity for all those influences which are always felt and especially so at this season of the year. Based upon a common professional interest in Electrical Engineering, the addition of broad human sympathies applied throughout the year cements friendships of enduring character,—"A man is known by his friends."

The rare privilege of visiting and meeting the membership of twenty-three sections of the Institute during the past four months and the inspiring hope of meeting the membership of thirty or forty other sections and branches during the next eight months has given great emphasis to this thought. When these peregrinations are completed, it is hoped to use one of these pages to record more of the resulting reactions.



Now, at this Christmas Season, let us draw about the blazing old time hearth of cheer and comfort to gather in to ourselves all that these days have to offer to each and every member of the Institute. Throw aside, at least for the moment, all of care or sorrow or pressing responsibility either of professional or personal character in the realization of a great brotherhood united in a common cause even greater and finer than that of its purely professional aspect.

May we hope that these blazing logs will radiate a cheerful, helpful thought and good wish to each member of the Institute at whatever distance.

Harold B. Smith

President

Some Leaders of the A. I. E. E.

William B. Jackson, Rate Engineer of The New York Edison Company and a member of the Institute since 1897 (Life Member), was its Manager from 1912 to 1915 and a Vice-President from 1918 to 1919. Coincidently, he was a Manager and Vice-President of the American Society of Mechanical Engineers, 1915; also President of the Western Society of Engineers in 1915. His papers before the Institute and Western Society of Engineers on *Advantages of Unified Electric Systems Covering Large Territories*, and *Hydraulic Developments as Related to Electric Installations* were in early presentation of the lines along which electric and power development has since progressed.

He was born at Kennett Square, Pennsylvania, June 23, 1870; and was graduated from the Pennsylvania State College in Mechanical Engineering in 1890 with the degree of B. S., later, in consideration of his work in electrical construction and operation, receiving the degree of M. E.

In 1894 he went with The United Electric Light & Power Company in New York City, but shortly thereafter entered the Test Department of the Stanley Electric Manufacturing Company at Pittsfield, Mass. He later became Assistant to Mr. C. C. Chesney, Chief Engineer, taking part in developing the equipment and designs for the first large transmission systems in California, undertaken by his company. In 1895 he was appointed his company's engineer for the Northwest, this service including the supervision of the construction and the starting of the 12,000-volt, two-phase transmission from Lowell to Grand Rapids, Mich., which was the first transmission of such high voltage east of the Rocky Mountains, and the distribution system. He later took temporary charge of this hydroelectric property, during which time he developed effective means for making all transmission line repairs while alive,—something new in the art for such high voltages,—to obviate the necessity of shutting down his Grand Rapids service for such repairs.

After returning to the Stanley Company, he supervised the installation and starting of engine generators on Staten Island for his company in 1897, and then remained with the Staten Island Electric Company as General Superintendent and Chief Engineer and Consulting Engineer of the Staten Island Electric Railway Company. During this period, he reconstructed the system for supply from a single generating station and changed it from single-phase 133-cycle, to two-phase 60-cycle operation.

In 1899 he became General Superintendent and Chief Engineer of the Colorado Electric Power Company, transmitting energy from its steam station in Canyon City to Cripple Creek District for various mine and ore reduction operations. Here again it was not practicable to shut down the single transmission line, so that it was necessary for him to develop means for repairing his 22,000-volt line while alive. The mine operators gradually became so impressed with the reliability of the service and with the possibilities of electric hoists, (which were also new in such work), that it became difficult to supply the demand. Due to the novel kinds of service, it was necessary for him to work out appropriate methods of charging for them.

Returning from this work to the Stanley Electric Manufacturing Company, he again took up problems of plant operation and development, including a comprehensive layout of hydroelectric development for the State of South Carolina, such as is now in progress in that territory. He also spent about six months in Europe for his company, studying European methods, including the electrification of railways.

After returning from Europe in 1903, he decided to form, with his brother Dugald C. Jackson, the Consulting Engineering firm of D. C. and Wm. B. Jackson. This firm soon opened offices in Chicago and Boston and was occupied with general engineering advisory work, design of electric plants and systems, and inventory and valuation of electrical properties until our country entered the World War, and both brothers entered the military service. Entering the Construction Division as Major in the United States Army in 1918, and taking charge of all operations and maintenance of electric lighting and power, refrigeration, buildings and grounds, roads, sewage and sewage disposal, water supply, heating, fire protection, etc., at Camp Merritt, N. J., the Chief embarkation camp of the Port of New York, Mr. W. B. Jackson later added to these the duties of Constructing Quartermaster.

Upon leaving the Government Service in 1918, he spent several years in consulting engineering work while operating his farm in Massachusetts, and was then employed by John W. Lieb, Vice-President and General Manager of The New York Edison Company, to work out engineering and rate problems. He has remained with that Company as Rate Engineer and in advisory capacity with its affiliated electric companies. He had general charge of the recent Inventory and Valuation of The New York Edison Company's entire property.

As Lieutenant-Colonel of the Engineer Reserve Corps, he has charge of matters relating to the U. S. Reserve Corps, Military Training Camps, and the Corps Area Engineer, for The New York Edison Company and its affiliated electric companies.

He is a member of the American Society of Mechanical Engineers, the American Society of Civil Engineers, the Western Society of Engineers, the Society of American Military Engineers, the Reserve Officers' Association, the American Legion, the Academy of Political and Social Science, and other important engineering, civilian, and military organizations. He is a member of the Engineer's Club of New York, the University Club of White Plains, and the Pittsfield Country Club. He also finds much pleasure in his farm in the Berkshire Hills.

A Recording Torque Indicator

That Records the Torsional Effort of Motors During Acceleration

BY G. R. ANDERSON[1]

Member, A. I. E. E.

Synopsis.—*The measurement of torque under unstable conditions of speed is usually extremely difficult and inaccurate when a dynamometer, prony brake, or similar torque measuring equipment is used. The device described in this paper was developed primarily to obtain torque measurements under unstable conditions as well as under stable conditions, and to obtain a permanent record of these measurements. It has been particularly successful in recording speed-torque curves of motors during acceleration and it can also be applied very effectively to other fields.*

* * * * *

INTRODUCTION

It is a relatively simple matter to measure, with a fair degree of accuracy, the speed and torque of an induction motor for any load between no-load and the pull-out point of the motor if the speed is steady. The static torque of the motor is also easily measured, but between these points where the speed is usually unstable, it is much more difficult to obtain satisfactory measurement. With the development of line-start motors, condenser motors, etc., it is becoming increasingly more important to know exactly the torque characteristics that the motor will develop. Dips in torque due to harmonics or other causes may be present in sufficient magnitude to seriously hinder the motor in accelerating its load. A device that will quickly and accurately record this torque should therefore find many uses in analyzing and improving motor characteristics. Such a device is described in this paper.

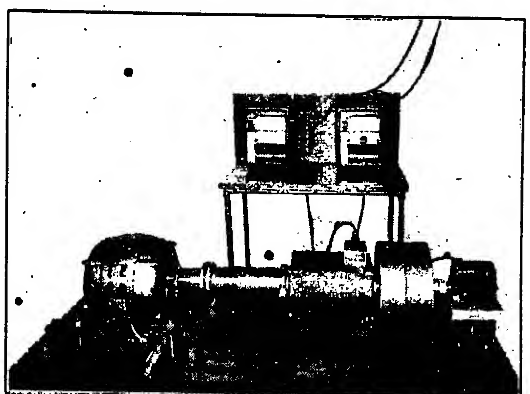


FIG. 1—TORQUE INDICATOR SET-UP FOR MEASURING STARTING TORQUE OF INDUCTION MOTOR

DESCRIPTION OF TORSIONAL INDICATOR

Fig. 1 illustrates the torsional indicator set up to take speed and torque curves on a squirrel-cage induction motor. The device consists of (1) a helical spring capable of transmitting the torque of the motor and giving an angular deflection proportional to the torque, and (2) an electromagnetic circuit of two elements that are displaced from each other by an angle equal to the deflection of the spring. A recording electrically-operated position finder is connected to the device to record the amount of angular deflection, which is proportional to the torque.

The helical torsion spring is accurately finished and is mounted so as to eliminate any distortion due to centrifugal forces. The spring is equipped with a damping sleeve that prevents fluctuations due to the natural period of vibration of the spring and elements, from being recorded on the chart. Full-scale deflection on the meter is obtained with a spring deflection of 60 degrees. Several sizes of springs can be interchangeably mounted to take care of various ranges of torque.

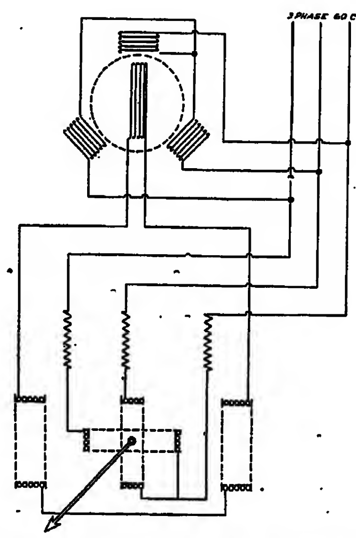


FIG. 2—CIRCUIT DIAGRAM OF TORQUE INDICATOR

The electromagnetic elements are mounted on two concentric cores, one of which revolves with the motor and the other with the load. The first element consists of a three-phase winding arranged symmetrically outside of the second element. This is shown diagrammatically in Fig. 2. This three-phase winding is

1. Development Engineer, Fairbanks, Morse & Co., Beloit, Wisconsin.

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excited through slip-rings from an external three-phase source of power. The second element contains a winding which is connected by another set of slip rings to the position finder as shown. The moving coils of the position finder are connected to the external source of power. When the first element is turned with respect to the second, the phase angle of the voltage generated in the second, is changed and this causes a deflection of the position indicator proportional to the torque. A tachometer generator and recording meter are used to measure the speed. The charts for recording both the torque and the speed are mounted on the same shaft in order to provide synchronized readings. Gear combinations in the tachometer generator allow different full-scale values of speed on the chart. It is obvious that the meter circuit can be so designed that the needle deflection is closely proportional to the angular deflection in the electromagnetic circuit of the device, thereby allowing the use of standard chart paper.

The device is similar in action to a d-c. meter in that it records average values and is well damped. It will not record very rapid fluctuations of torque but it does produce fairly accurate quantitative measurements.

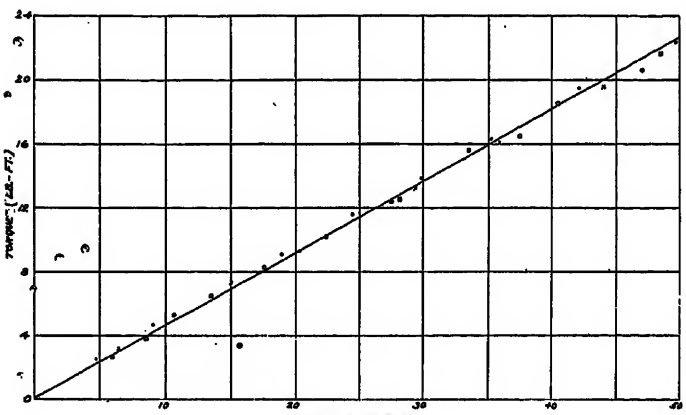

FIG. 3—CALIBRATION CURVE OF TORQUE INDICATOR

. —1800 Rev. per min.
x —1200 Rev. per min.
0 — 600 Rev. per min.
□ — 0 Rev. per min.

CALIBRATION

Calibration of the device is accomplished by placing it between a dynamometer and a load and recording the torque output of the dynamometer and the instrument reading. Fig. 3 is a calibration curve for a given spring showing the relation between actual torque and instrument reading. The plotted readings were taken over a wide range of speed and of torque and clearly indicate that centrifugal force has no serious influence on the accuracy of the device. While the calibration curve is actually slightly S-shaped, for practical purposes it may be considered a straight line, since the error introduced by such assumption is extremely small.

METHODS OF LOADING

Since this device indicates transmitted torque and speed simultaneously and records these values on a chart, it is obvious that any suitable method of loading can be applied. In the case of taking speed and torque curves on motors during acceleration it has been found that a simple flywheel load is most satisfactory. Under these conditions, the entire torque output of the motor is utilized to accelerate an inertia load, neglecting friction, and the rate of acceleration is proportional to the torque transmitted at that speed. The rate of acceleration can be readily determined from the speed-time chart. The torque indicated on the chart is the torque transmitted through the spring, and is equal to the torque developed by the motor less that required to accelerate its rotor. Thus the indicated torque during acceleration will be slightly less than that shown at stable speeds and will be proportional at all speeds to the ratio of the WR^2 of the flywheel and device to the WR^2 of the entire rotating mass. By calculating the WR^2 of the rotor and determining the rate of acceleration from the chart, the ratio of developed torque to transmitted torque can be found. It is obvious that this ratio will hold constant for all conditions of acceleration of a simple flywheel load.

In practise the torque available for bringing a load up to speed is the developed torque less that necessary to accelerate the rotor so that the indicated torque as produced on the chart actually represents the torque available at the shaft for the accelerating period as shown. In general it will be found that when the accelerating period exceeds 15 or 20 sec., the difference between the developed torque and transmitted torque will be less than four or five per cent. The necessary time to allow for full acceleration of a motor should not be less than 10 or 15 sec. in order that the pen of the instrument may follow accurately the changes of torque. It has been noted also that accelerating periods of 20 to 30 sec. usually cause such a small change in motor temperature that this factor can be neglected.

In the following examples the instrument chart speed was 12 in. per min., each cross-division representing a time of 3.75 sec.

APPLICATIONS

Fig. 4 is an example of speed and torque charts taken on a 5-hp., 1800-rev. per min., 60-cycle, repulsion-induction motor. The variations in torque at start due to the commutator are clearly shown as well as the point of operation of the short-circuiting device and change over from repulsion to induction torques. Charts of this kind were taken to show the effect of setting the short-circuiting device to operate at different speeds.

Other charts taken on repulsion-induction motors, clearly show the change in shape of the repulsion torque curve due to change in brush setting and the lowering

of pull-in torque when the brushes are displaced from neutral by more than the proper angle.

Fig. 5 shows records taken on a line-start squirrel-cage induction motor. In addition to the charts of torque and speed, synchronized charts that recorded the current and power input were also obtained with a constant voltage applied to the terminals of the motor. Several of these motors with different types of rotor construction were tested in order that an accurate comparison of the characteristics of each type might be obtained.

It was noted from the charts that each of these motors having a rotor winding of special shape designed to lower the current drawn by the motor from the line during starting, had an appreciable dip in accelerating torque. The knowledge thus obtained of the exact amount of accelerating torque at all speeds should prevent misapplications of these motors.

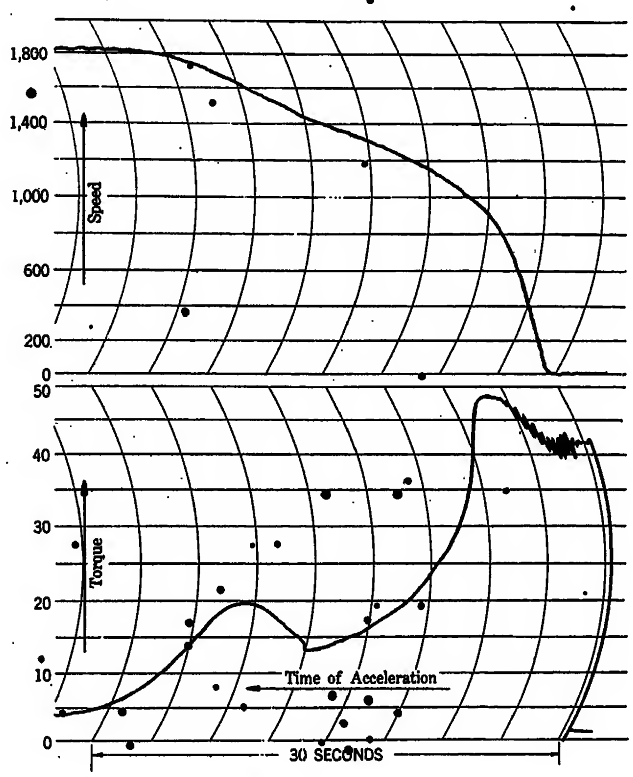

Fig. 4—Speed and Torque Curves of Repulsion-Induction Motor during Starting

This is a 5-hp. 1800-rev. per min. 60-cycle, 220-volt single-phase motor

By means of the addition of current and wattmeter readings, the factors affecting the developed torque of the motor can be determined from tests for all speeds. The change in rotor resistance and reactance with changes in slip can be calculated and the value of any particular type of rotor construction for a given condition can thereby be determined.

In making tests on squirrel-cage induction motors it was found that invariably the indicator recorded distinct torque pulsations whenever the motor became noisy. Investigation with this device also verified the general belief that dips in torque due to harmonics in squirrel-cage motors are more pronounced at low voltage than at high voltage. A series of curves taken on a motor with different values of voltage applied to the terminals showed a damping out of harmonics as

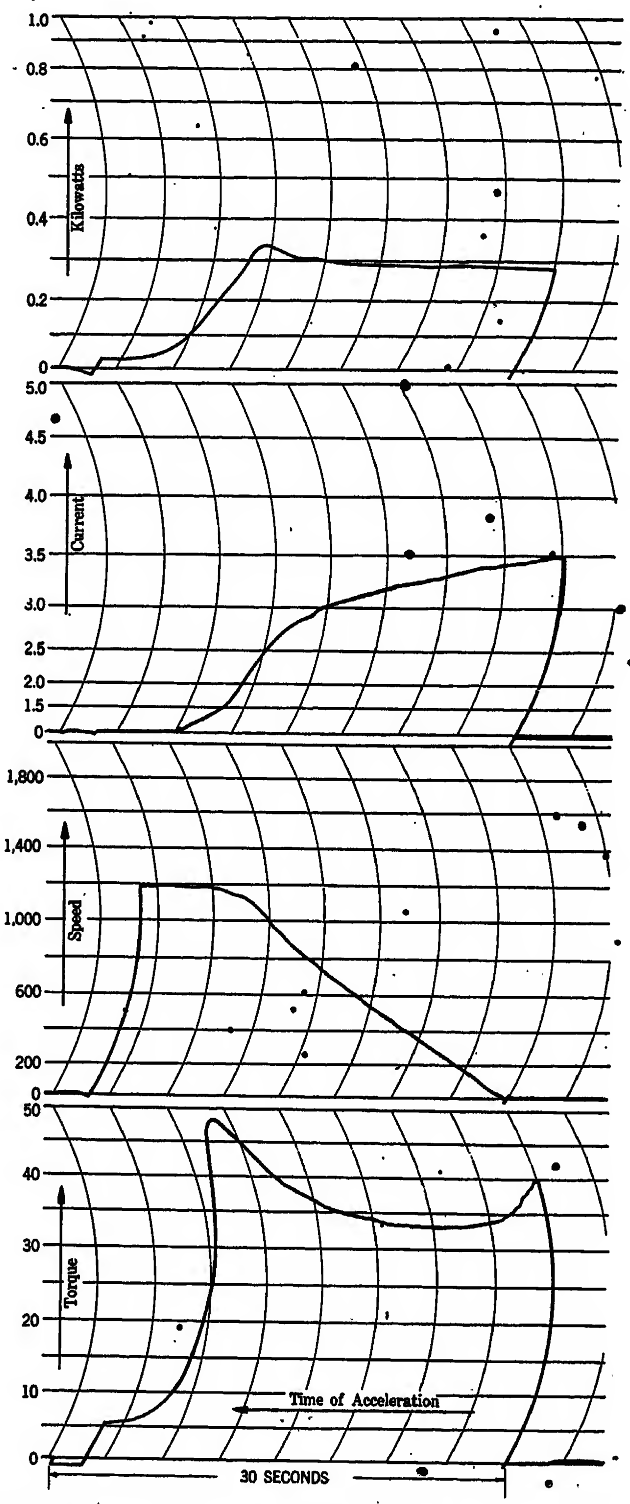

Fig 5—Records Taken during Acceleration of a Line-Start Induction Motor

Curves are shown for kw., amperes, speed, and torque of a 20-hp. 1200-rev. per min. three-phase 60-cycle motor

the voltage was increased. It seems reasonable therefore to assume that if a motor develops a satisfactory speed-torque characteristic on reduced voltage, it will show an equally satisfactory characteristic at any higher voltage.

The charts shown here illustrate the speed and torque characteristics of motors of various types. It is quite apparent, however, that a recording torsional indicator can be used to advantage also in many other fields of investigation. For example, its operation can be reversed and in place of recording the torque output of a motor it could record the torque necessary to start and run a given load. By so doing definite data could be obtained as to the load and the most economical type and size of motor could be applied.

ACKNOWLEDGEMENT

The writer wishes to acknowledge the valuable assistance given by Mr. D. J. Angus of the Esterline Angus Company in developing the meter for this device.

Automatic Regulation of Synchronous Condensers Equipped with Superspeed Excitation

BY L. W. THOMPSON[1] and P. J. WALTON[2]
Non-member Member, A. I. E. E.

Synopsis.—This paper describes extensive field tests made on the super-high-speed excitation equipment used with the 30,000-kv-a. synchronous condensers at the Plymouth Meeting Substation of the Philadelphia Electric Company. Oscillograms and calculated curves showing the performance of the synchronous condensers with this equipment are included, together with a discussion of the results obtained.

* * * * *

THE speed and maximum voltage characteristic of the excitation system used on synchronous condensers is of prime importance in determining the amount of corrective kv-a. which can be furnished by the condenser during a system disturbance.

On the Conowingo Line at the Plymouth Meeting Substation there are installed three 30,000-kv-a. condensers equipped with a supersystem of high-speed excitation and a method of control that is sufficiently novel to warrant a general description.

To obtain the same corrective kv-a. with ordinary types of excitation, a much larger installation of condenser capacity would be required.

These machines are installed for the purpose of voltage regulation of the system and as an aid during transient conditions. Since other articles have described the synchronous condensers, no description is given herein.

Excitation for the main exciter field is furnished from a subexciter. The subexciter itself is of standard design and is a straight shunt-wound machine. The main exciter is of very special design. It has laminated poles and yoke, heavy series winding (which will be referred to later), and an armature ceiling voltage of approximately 1000. Also, it is provided with two shunt-field windings.

The main shunt field is directly connected to the subexciter through a simple motor-operated rheostat which if properly set will give in general the proper main exciter volts to produce the desired kv-a. on the condenser under steady conditions of load and voltage.

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At this time there will be little or no current in the second or regulating shunt field on which the regulator contacts operate. This of course is very desirable.

This regulating or auxiliary field itself will not produce an exceedingly high rate of rise of the exciter voltage, but can take care of ordinary conditions of load and voltage that may come during normal operation. This range of the auxiliary field itself is somewhat unusual as it is capable of controlling the condenser from approximately 20,000-kv-a. lag to 60,000-kv-a. lead under all steady-state conditions, and if there were any requirement for it even this range could be extended.

The regulator is of the high-speed type equipped with a three-phase torque motor as the master voltage element, so as to provide proper response of the regulator on any type of disturbance. The relay contacts of this regulator are connected to the auxiliary field through an unbalanced resistance bridge so that a reversal of the auxiliary field can be obtained, depending on the ratio of time opened to time closed of these relay contacts. This regulator controls the line voltage under normal conditions because of its ability to vary the condenser kv-a. through the above mentioned range.

However, for transient conditions, resulting from line-to-ground, double-line-to-ground, or three-phase faults when the average line voltage is depressed five per cent or more, the main shunt field is brought into play by means of a second master voltage relay which operates a high-speed contactor, opening the regulating field and cutting out the resistance in series with the main shunt-field winding. When this resistance is cut out of the main field, a rate of rise of approximately 7000 volts per sec. is obtained on the main exciter. This resistance is not cut-in again until the line voltage is

restored or until the kv-a. per condenser has reached approximately 60,000.

At this time a current relay in the main condenser field operates at a value corresponding to this maximum kv-a., which again inserts the resistance in the main exciter field, the auxiliary field being closed simultaneously with the insertion of this resistance. This transition between the two shunt fields is very smooth and

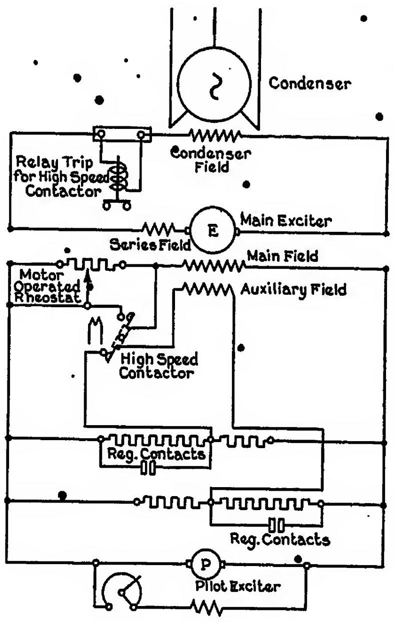

FIG. 1—HIGH-SPEED EXCITATION SCHEME FOR SYNCHRONOUS CONDENSER

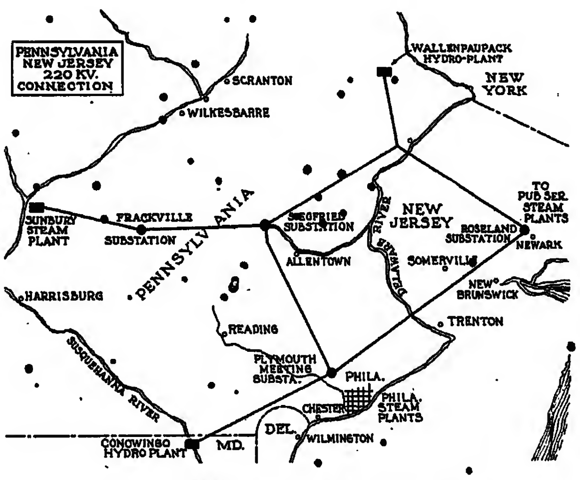

FIG. 2—MAP OF INTERCONNECTION

does not produce fluctuations to any extent in the main exciter voltage, or any fluctuations in the kv-a. on the main unit, as the transformer action between these fields tends to keep the flux constant. As the main field tends to collapse, it induces substantially a corresponding increase in ampere-turns in the auxiliary field sufficient to maintain the original flux produced by the main field. After this change the regulator again operates upon the auxiliary field either to maintain voltage or a maximum kv-a.

At a time when conditions return to normal, the regulator rapidly backs the exciter voltage down from its original high value to the value required to give the proper voltage on the system bus. This rapidity of die-

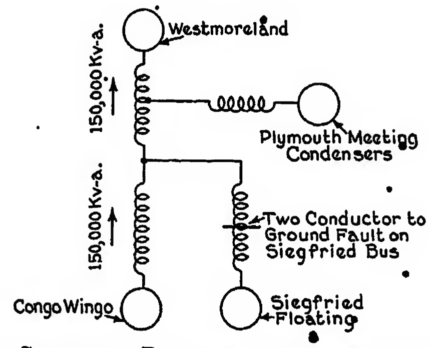

FIG. 3—SCHEMATIC DIAGRAM OF SYSTEM UPON WHICH CALCULATIONS WERE BASED

The fault F on Siegfried bus results in a decrease in positive phase sequence voltage at the terminals of the condensers of 30 per cent and an increase in positive phase sequence condenser current of 208 per cent.
Conowingo assumed to be furnishing 150,000 kv-a. to Westmoreland

down is due to the auxiliary shunt field at this time receiving a reversed voltage, which in turn accelerates the decay of the main exciter. This scheme of connections is shown in Fig. 1.

DISCUSSION OF CURVES AND CALCULATIONS

The benefit derived from superexcitation in regard to increased condenser capacity can best be understood by considering a specific example.

The diagram of system connections is shown in Fig. 2; schematic diagram of system in Fig. 3.

Consider Siegfried, Conowingo, and Westmoreland interconnected, Siegfried floating on the line, and Conowingo feeding 150,000 kv-a. to Westmoreland. If a two-conductor-to-ground fault occurs at F on the Siegfried bus and two condensers are operating at

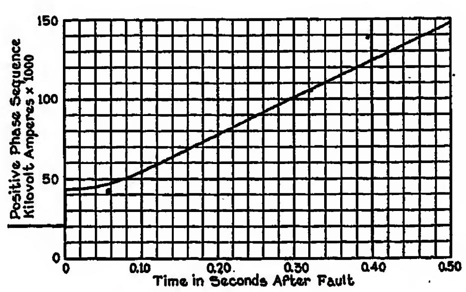

FIG. 4—GRAPH SHOWING RISE OF CONDENSER KV-A. AFTER TWO-CONDUCTOR-TO-GROUND FAULT

Plymouth Meeting at 10,000 kv-a. leading, giving a total of 20,000 kv-a., there will be an instantaneous rise to 43,000 leading kv-a. from the Plymouth Meeting condensers at the moment of fault.

After the fault has been applied, the condenser kv-a. will continue to rise as determined by the superexcitation system from the above-mentioned initial value of

43,000 kv-a. to approximately 150,000 kv-a. in 0.5 sec. This is shown graphically in Fig. 4.

From Fig. 5 it is seen that two condensers with standard excitation are, at the first instant, equal in corrective effect to two condensers with superexcitation, but at the end of one-half second, approximately ten

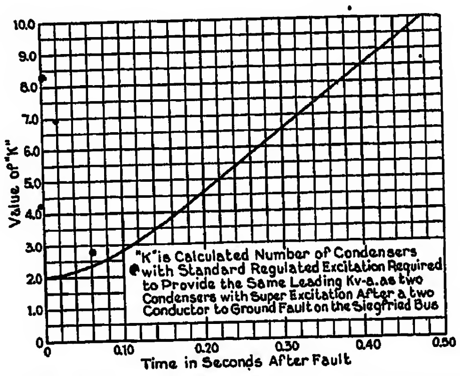

Fig. 5—Curve Showing Number of Condensers Needed with Standard Excitation to Give Same Correction as Two Condensers with Superexcitation

Before the fault occurs it is assumed that the condenser bus voltage is being held at its proper value by the 20,000 kv-a. delivered by the two connected condensers. In order to deliver this same initial kv-a. with a larger number of condensers with ordinary excitation, the excitation on each condenser would necessarily be less than that of either one of the two units with superexcitation.

Referring to Fig. 5, the integrated kv-a. or kv-a. seconds shown, could be furnished by approximately five and one-half condensers with standard excitation at the end of 0.5 sec., but the maximum instantaneous kv-a. at the end of 0.5 sec. with two condensers having superexcitation is approximately equal to ten condensers with ordinary excitation.

Requirements

It was required of the condenser that it be capable of operating at 10,700 kv-a. lag up to 55,000-kv-a. lead; also with the condenser carrying 10,000 kv-a. lead initially, the time from the occurrence of a fault on the

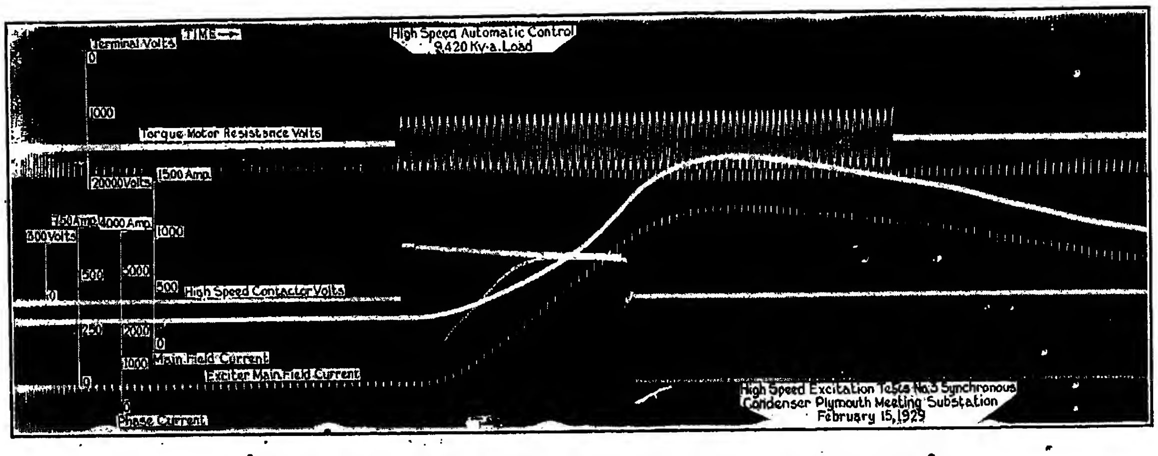

Fig. 6—Oscillograph Records of High-Speed Excitation Tests

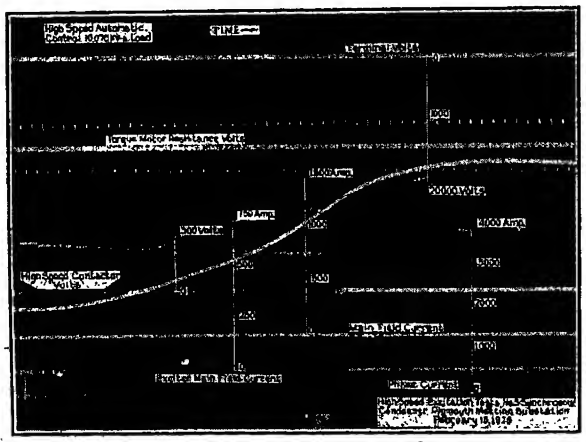

Fig. 7—Oscillograms of Test on Condenser Having High-Speed Excitation

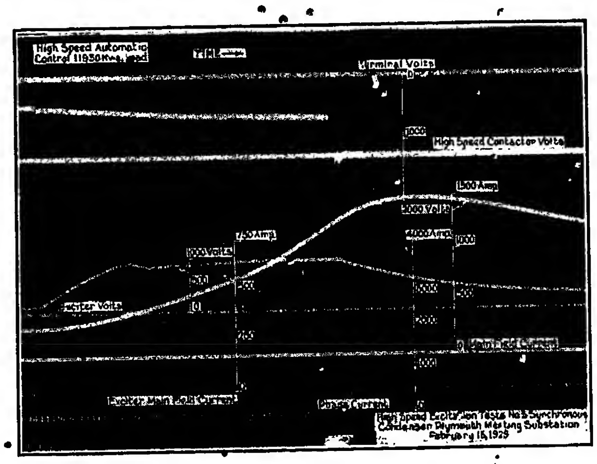

Fig. 8—Oscillograms of High-Speed Excitation Test

condensers with standard excitation are required to give corrective effect equivalent to two condensers with superexcitation.

system to reaching 55,000-kv-a. lead to be not more than 30½ cycles on the basis of 60-cycle time, the exciter voltage to be not more than 900-volts ceiling.

These requirements meant that the voltage regulator

must operate over a range of from about zero volts to 900 volts.

This condition will be appreciated when it is remembered that the usual voltage regulator is required to operate over a range of from 70 to 140 volts or a range of 1 to 2.

In case of a short circuit on a line, it is possible for the voltage of one-phase to be higher than before the short circuit occurred and for this reason, the voltage-regulator element and the element for applying the super-excitation each consists of a three-phase torque motor.

To insure the high-speed feature being applied independently of the regulating equipment used for normal conditions, and to have it come in with the least amount of time delay after the occurrence of a fault and to adjust the voltage at which it would be applied independently of other conditions, a separate torque motor was used for the purpose of applying the high-speed excitation in addition to the torque motor operating as a normal voltage regulator.

Tests

The kv-a. taken by a condenser for a given field current depends upon the voltage at the condenser terminals. It was impossible to hold constant voltage when suddenly increasing from 10,000 kv-a. to 55,000 kv-a. owing to the reactance of the transformer bank, to the tertiary winding of which the condenser is connected.

In testing, therefore, to determine the time to increase from 10,000 kv-a. to 55,000 kv-a., the starting point was taken as the field current to produce 10,000 kv-a. at rated voltage 13,800 volts; and at the starting point, the voltage was reduced by having lagging kv-a. on another condenser to try to reach 13,800 volts when the kv-a. reached 55,000 on the condenser under test.

In other words, the time is that required to build up the field current of the condenser, as the a-c. amperes depend on the condenser field flux, and tests showed that there was practically no time delay between field amperes and a-c. amperes and consequently field flux.

Referring to Fig. 6, the torque motor resistance is the voltage across a resistance inserted in the torque motor circuit to reduce the voltage applied to the torque motor to correspond to a short circuit on the system.

When the system voltage dropped as indicated by the voltage across this resistance, it will be noted that within a cycle, the torque motor contact closed, applying voltage to the coil of the high-speed contactor.

The instant when the high-speed contactor closed is indicated by the point when the exciter main field current starts to increase.

Following the short-circuiting of the resistance in the exciter main field by the high-speed contactor, the field current of the main exciter rapidly increases, building up the exciter voltage to the desired value, approximately 900 volts, as shown in Fig. 7. After this the exciter voltage held practically constant because of the combined effect of lowering the pilot exciter voltage by omitting its series field and by the action of the series field of the main exciter. This is also shown in Fig. 8.

With the adjustments used, the kv-a. of the condenser built up to about 73,000, or well beyond the 55,000 kv-a. agreed upon.

Summarizing these tests, the time required to reach the required kv-a. is approximately 25 cycles on a 60-cycle basis, though in actual practise the required kv-a. would be reached much earlier because of an instantaneous increase of kv-a. through a reduction in terminal voltage resulting from a short circuit on the line, to which is added the subsequent increase due to the high-speed excitation. Additional benefit in regard to rate of rise is obtained from a very heavy series field on the main exciter which tends to raise the exciter voltage due to the transient increase in the condenser field current, raising the exciter voltage before any of the automatic equipment installed for this purpose comes into play.

ELECTRICITY APPLIED TO STRIP COAL MINING

More than a thousand people traveled from Chicago, St. Louis and other cities to the Fidelity Mine of the United Electric Coal Company, near Duquoin, Ill., on November 7, to see an electric shovel said to be the biggest in the world, which is used for stripping the earth from the coal vein which is being mined.

The shovel was designed for use with a 20-cu. yd. bucket, but this size was reduced to 15 cu. yd. in order to permit an extension of the boom. The reach of the dipper is sufficient to place material about 85 ft. above the ground. The complete shovel weighs approximately 1650 tons. It is operated by one man by means of Ward Leonard control on the conversion equipment supplying direct current to the motor. The 4000-volt alternating-current power supply drives a five-unit motor-generator set consisting of a 1700-hp. motor, one 860-kw. generator, two 350-kw. generators and a 50-kw. exciter.

The electrical equipment was furnished by the General Electric Company. A very large tipple designed by the Jeffrey Manufacturing Company serves seven railroad tracks and has a capacity of 800 tons of coal per hour. The tipple is operated by 43 electric motors ranging from 3 hp. to 150 hp. and aggregating approximately 1000 hp. Nearly all are three-phase, 60-cycle machines operating on 440 volts, and with but few exceptions they are standard slip-ring induction motors. Virtually all are operated by magnetic push-button control.

Series Synchronous Condensers
for Generation of Voltage Consumed by Line Inductance

BY THEODORE H. MORGAN*

Associate, A. I. E. E.

Synopsis.—The factors determining the power-carrying capacity of a transmission system are briefly discussed in this paper. The principal effects obtained by the operation of synchronous condensers used to compensate for the system consumption of lagging reactive kv-a. are pointed out. This method of compensation is contrasted with the direct method of supplying the reactive kv-a. to the line in the manner in which it is consumed, i. e., by the series method.

A plan for obtaining direct or series reactive kv-a. compensation by a method employing electric machinery is described. This includes a description of a method for producing the required voltage and inserting it into the system.

Some of the characteristics of operation and advantages to be gained by the use of the described method are given.

* * * * *

PRINCIPLES AND PRACTISE

A COMPLETE investigation of the transmission line power-limit problem shows that in the final analysis the limit of the amount of power which can be transmitted over a given system at a fixed maximum voltage and load power factor is determined by the total series inductive reactance of the system. The combined inductive reactance effects of the circuit, from the point of generation of the internal e. m. f. in the alternator to the point of voltage drop due to the e. m. f. of the load end machinery, determine the maximum amount of power that can be transmitted from the rotor of the generator to the rotors of the load machines.

The inductive reactive kv-a. of the load has its influence in limiting the maximum power which a system can transmit. An understanding of this principle, combined with the necessity of maintaining constant voltage at the load, has led to the practise of operating synchronous condensers at the load end of the line. These condensers may be considered as a source of inductive reactive kv-a. capable of compensating totally for load power factor, but only partially for line consumption of reactive kv-a. Such a method of compensation gives load end voltage control while increasing the system power limit. In fact, voltage control and reactive kv-a. compensation are interrelated, one action accompanying the other. The ultimate power limit is reached with the limit of compensation. The important fact related to synchronous condenser operation at the load end of the line is that complete compensation for line effects becomes impossible with increasing load, and the load and generator machinery finally fall out of step because of the inability of the system to transmit the load required of it.

About a year and a half ago, in an attempt to test out a new practise, an installation of series capacitors was placed in operation on a transmission line.[1] Such capacitors provide a method of series inductive compensation which is direct and inherently automatic. They produce a voltage across them which is opposite in phase angle to the voltage caused by the inductive reactance of the line. By proper choice of the capacitor size these two voltages may be made to entirely counteract each other, thus compensating for the inductive effects of the system. The line effects are completely eliminated and the amount of power which it is possible to transmit is very materially increased.

General Methods. It may be said that there are in general two methods by which reactive kv-a. may be supplied to a transmission system. First, it may be furnished indirectly by apparatus connected across the line in a manner similar to an ordinary load; or second, it may be added in a direct manner through apparatus connected in series relation to the line conductors. Each method gives compensating effects which are different in character and results obtained.

The first method changes the phase angle of the line current with respect to its voltage and in this way produces a line drop at such an angle that the load end voltage is held constant at a required value which may be equal to that of the generator end. This is shown in a simple case by the vector diagram of Fig. 1, in which the line charging current and resistance drop are omitted. With increase of line current, the angle between the generator-end voltage and the load current increases and the compensating reactive power supplied must increase with the load in order that the load voltage may be maintained. The maintenance of synchronism between generator and load is dependent entirely upon this principle when the phase angle between load current and generator-end voltage becomes large. This is because the power represented by these two quantities considered by themselves becomes diminishing under these conditions.

In the second method, the compensation is obtained by the addition of a series voltage to the system. This plan does not alter the line current, but the reactive kv-a. is produced by the inserted voltage acting with this current. The compensation is direct and the reactive kv-a. is supplied in the same manner that it is

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1. See Bibliography 2 and 3.

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consumed. Referring to Fig. 2, E_L, the voltage produced by line inductance is counteracted by the voltage E_C, equal to it and opposite in phase angle. In this case the line effects have been completely compensated for, and the load end voltage becomes identically equal in magnitude and phase to that of the generator end.

A New Method

The problem at its present status would seem to demand that all possibilities and options should again be investigated. With the belief that the direct or second method is preferable to the one now commonly used, an attempt has been made to develop a plan by which the desired results may be obtained by the use of electrical machinery. It was realized that if a voltage identical both in magnitude and phase to that produced by series capacitors be generated and applied in series to the circuit, effects similar in general character to those realized by capacitors may be obtained. The following system of machine operation has been devised for this purpose.

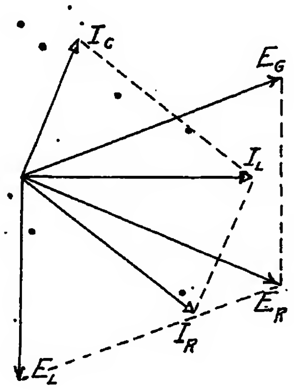

Fig. 1—Vector Diatram showing Compensation with Synchronous Condenser

E_G is generator end voltage
I_R is load current
I_C is correcting current
I_L is line current
E_L is voltage produced by line inductive reactance
E_R is load end voltage

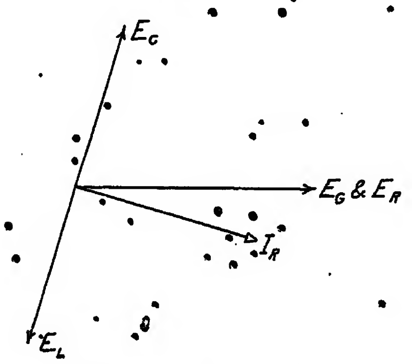

Fig. 2—Vector Diagram showing Direct Compensation

E_G and E_R are generator end and load end voltages
I_R is load current
E_L is voltage produced by line inductance
E_C is voltage supplied by correcting apparatus

Description. The general plan of arrangement is shown by the wiring diagram of Fig. 3. The reactive kv-a. required for compensation is supplied by a machine similar in construction to a synchronous condenser, which for want of a better name will be called the "inductive compensating generator." This machine is driven at synchronous speed by a synchronous motor, operated in the ordinary way from a bank of transformers connected across the line.

The voltage to be supplied to the line by the driven machine should be proportional to the line current since its purpose is to compensate for a voltage caused by this current flowing through the line inductive reactance. With the iron of the magnetic circuit of the machine below the point of saturation, this would require an exciting current which is at all times proportional to the alternating current of the line. This immediately suggests using the line current for machine excitation purposes. This current may be passed through current transformers to obtain a suitable magnitude, then rectified with a polyphase mercury arc or other rectifier, and passed through the field circuit of the machine. Special current transformers with sufficient iron in the core would produce voltage impulses on sudden changes of line current, thus providing rapid response in machine excitation.

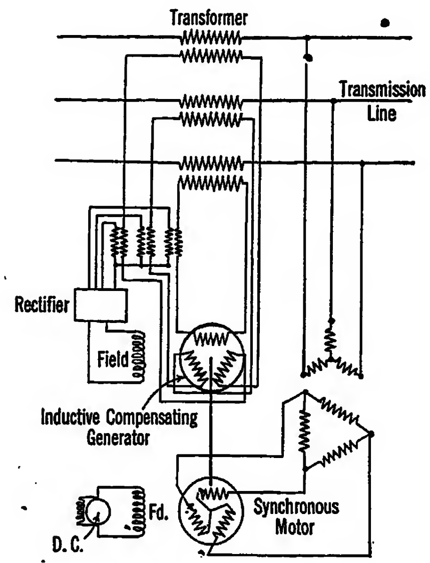

Fig. 3—Wiring Diagram of Arrangement of Apparatus

The requirements of frequency and magnitude having been met, there is the question of maintenance of proper phase relation for the compensating voltage. Due to its inherent characteristic, the driving synchronous motor would hold the rotor of the inductive compensating generator to an approximately constant phase position with respect to the line voltage. If it were possible to maintain constant power factor on the line, this is all that would be required, once the original setting of the angle between the two rotors had been correctly adjusted. However, since there is a pos-

sibility of change of line power factor angle with change of load, it would seem that provision should be made to meet this contingency. The machine should normally operate with the voltage which it produces in leading quadrature relation to the current through it. By arranging the stator of either the driving motor or the inductive compensating generator so that it can be moved in such a way as to alter the relative phase angle between their armature windings, the required condition can be maintained. The real power output will always be zero and the stator position could be automatically controlled to produce this condition for all phase positions of the line current.

In cases where compensation is to be made on relatively low-voltage lines, the separate phase windings of the machine could be connected directly in series with the line wires. When used on high-voltage lines transformers would be necessary. These transformers would have their high-voltage windings placed in series with the transmission line wires and low-voltage windings connected to the machine phases. Such transformers would perform both series and potential duty and in addition, insulate the machine from the line voltage. They would act as series or current transformers in permitting passage of line current, the ampere-turns of both windings being equal. In stepping-up and introducing the machine voltage into the line they would be doing potential transformer duty.

With the inductive compensating generator being driven so that its generated e. m. f. is in leading quadrature to the current in its windings, there will be no torque or power developed by the machine. However, it will be operating in a condition of unstable equilibrium. By this is meant that on any relative displacement of the rotor and stator from the required position, a torque will be produced which will tend to still further increase the displacement. This torque will increase with the amount of the displacement up to the 90 electrical degree angle in either direction. The position of 180 electrical degrees from the required operating position is the stable one, and the rotor would seek this position if allowed to do so. In order to maintain the desired operation it is necessary that the driving motor be designed to produce more torque for small angles of displacement than that produced by the driven machine. Under normal operation the load on the driving motor would be very small as it would only be required to supply the rotation losses of the compensating machine. Thus for the driving machine, there would be required a relatively small motor with special characteristics.

Characteristics and Advantages. When this plan of compensation is applied to very long lines it might be desirable to insert a number of compensating units at intervals along the line, so that the supplied voltage would not be excessive at any single unit. This would also aid in keeping the line voltage more uniform throughout the entire length. For all cases of complete compensation, irrespective of the number or location of the units, the total reactive kv-a. supplied would be equal to the inductive reactive kv-a. consumed by the line if the line charging kv-a. be neglected. Also complete compensation by compounding the line inductance voltage would eliminate, in every case, its detrimental effects on voltage regulation and power-carrying capacity, leaving only the factor of line resistance.

The one operating benefit derived from line inductance is its effectiveness in limiting short-circuit currents. If the compensation were sufficiently complete to counteract all inductance effects of the line and transformers over the range of all possible currents, the short-circuit currents would be excessively high. The machine system of compensation, however, has the decided advantage that the magnetic circuit of the machine becomes saturated at certain currents and that its compensating ability is thus limited. As a result of this characteristic of the machine, it is possible to obtain full compensation up to a critical current, after which any appreciable increase in compensation becomes impossible. The effect desired is obtained by the inherent characteristic of the machine without any supplementary control. In this respect, compensation by machinery is far superior to that obtained with a series capacitor, which must be short-circuited on heavy currents with the resulting system disturbance upon its subsequent return to the circuit. With machine compensation, on the disappearance of the heavy line current, normal operation is restored by smooth action as the excitation on the machine is reduced.

In other respects it would seem that all the advantages claimed for series capacitor operation would apply to this method.

The inductive compensating generator is connected to the circuit in such a way that it will not supply its storage of rotational energy to a short circuit in the manner in which a synchronous condenser operates under such conditions.

Conclusion

The above described system of inductance compensation has been devised with the hope that it may in some small way point toward the solution of a vital problem in power transmission. No claim is made that the general plan is finally or completely worked out in all its details. On the basis of conformity to present practise, it will have no advocates. Because of its departure from methods now employed, many matters realized only through operating experience are as yet undetermined. However, granted that the general plan is fundamentally sound, its success must be inseparably linked with the ability to maintain complete, dependable, automatic machine control. In this regard it may be said that the rapid advance which is being made in the art of electrical controls is positive proof that this phase of the problem can be satisfactorily solved when the demand arises.

ACKNOWLEDGMENTS

The author wishes to express his appreciation to the faculty of the Electrical Engineering Department of Stanford University for many helpful suggestions, and particularly to Dr. Harris J. Ryan for his inimitable encouragement and assistance in the development of this plan.

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The Future of Higher Steam Pressures in Steam Electric Generating Stations

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Fellow, A. I. E. E.

***Synopsis.**—Construction and operating experience has shown that a large part of the theoretically possible gains in efficiency due to higher steam pressures has been obtained in practise.*

What are the future possibilities of higher pressures?

The biggest problem before station designers today is to reduce the cost of construction per unit of capacity. Some engineers have suggested that we should build cheaper and less economical stations. This is an unsatisfactory answer to the problem. The proper answer is to maintain the high standards of efficiency that have been established and reduce the cost of construction by intensive study and better design. Better engineering in the future is the answer to the problem.

By the use of large turbine generator units and large steam generating units, the unit cost of construction can be reduced materially. The present practise of installing several boilers to serve one turbine generator increases the cost of construction. The use of large steam generating and turbine generator units will reduce the unit cost of high-pressure stations more than it will reduce the unit cost of normal pressure stations.

If the steam generating units match the turbine generator units in capacity, we can design for unit construction. This unit construction will not only reduce the cost of construction but will also simplify operation.

* * * * *

MUCH has been written about the present state of development in the use of higher steam pressures in steam electric generating stations. The plants in service and under construction have been discussed at length in the technical press, and it would be useless to endeavor to present to you a detailed picture of what has been accomplished. It is sufficient to say that a large part of the theoretically possible gain in efficiency has been obtained in practise, and there is every reason to believe that we will, in the near future, obtain as near the theoretical efficiencies possible as we have in stations designed for more moderate operating pressures.

It would appear to be of more use to attempt to take stock and discuss the future possibilities of higher pressures.

In meeting our every-day problems, we are prone to see only the immediate job before us and to lose sight of the broad economic problem with which we are dealing. It is becoming more and more necessary to keep the broad problem before us continually and to so conduct our every-day work that it will fit into the larger picture to the best advantage.

A résumé of the accomplishments of the past is helpful only in focusing our attention on the possibilities of the future. The work done so far in raising the operating steam pressure has produced results that are very satisfactory. They are satisfying principally, however, because they indicate that we have made progress and lead us to believe that we will continue to do so in the future.

Looking back at the development of the steam electric generating station since Mr. Edison started the Pearl Street Station in New York City, what can we learn of particular moment to guide us in the design of new stations?

Many things have been accomplished and the best of these should be incorporated in the new installations that we are about to make.

Many costly mistakes have been made and these should not be repeated, for while it is excusable to err, to repeat an engineering error is an economic waste.

Let us select for discussion a few salient points of a general nature, and let us confine ourselves to those points that need to be kept constantly before us in our new designs.

First and foremost, we find that in the past we have so designed our stations that the fixed charges on the cost of construction are several times the combined cost of fuel, maintenance, and operating labor. It is therefore apparent that by attention to this fact we can make the largest saving in the cost of generating electrical energy. This problem undoubtedly takes precedence over all others before the industry today. What is the answer?

1. Chief Engineer, The Edison Electric Illuminating Company of Boston, Boston, Mass.

Presented at the Great Lakes District Meeting of the A. I. E. E., Chicago, Ill., Dec. 2-3-4, 1929. Printed complete herein.

Some engineers have gone so far as to recommend that we forget our efforts for higher thermal efficiencies and build cheaper and less economical generating stations. That is not a satisfactory answer. It is not right that we should cast aside the accomplishments of the past, for the facts of the case prove that those accomplishments have resulted in reducing the cost of supplying electric service.

What we should do is to maintain the higher efficiencies that have been obtained and at the same time reduce the cost of construction by more intensive study and better design.

Better engineering in the future is the answer to our problem.

We are doing better engineering today than in the past because of the accumulated engineering data available and because of the extensive research work of the past few years. Better engineering will result in more economical designs, more economical use of the materials of construction, more economical production, greater simplicity and ease of operation, and probably higher thermal efficiencies.

As a matter of fact, we are fortunately trapped by circumstances for our own good. We cannot afford to build stations today of the same design as those built a few years ago. A careful study will show that if our fuel cost us nothing we could not afford to build stations with as low thermal efficiencies as were built ten or fifteen years ago. No! The answer to the problem is not to take a backward step but to go forward. By better design we can maintain the high standards of efficiency and at the same time reduce the cost of construction and the fixed charge item in the cost of supplying electric service to our customers.

As electrical systems have grown in size, the capacity of the prime movers and generators has grown likewise. The use of larger turbine generator units, when intelligently used, has reduced the unit cost of generating stations irrespective of the operating pressure. However, it appears from the facts available at this time that the use of large turbine generator units favors the higher pressure stations more than it does those designed for more moderate pressures. Today a 50,000-kw. unit for 1200-lb. pressure costs somewhat more than one designed for 350-lb. pressure, but a 125,000-kw. unit costs about the same whether designed for 1200- or 350-lb. pressure.

It would therefore appear advisable in high pressure stations to install as large-sized turbine generator units as practical from the operating standpoint. The recent designs of turbines that give practically the same economy over wide ranges of load have made it advisable today to use larger units than would have been advisable a few years ago for the same system load conditions.

Interconnections of electric systems also permit the installation of larger turbine generator units than would be advisable without interconnections. This factor should not be lost sight of if the fullest advantages are to be obtained by interconnections.

In the past, the size of our steam generating units in our stations has always lagged behind the size of our turbine generator units. From three to five boilers are often installed to serve one turbine generator with a resultant large increase in the unit cost of our boiler plants when compared with a design in which the steam generating unit matches the size of the turbine generator unit.

There seems to be no basic reason why the steam generating units should not match the turbine generator units in reliability. Already steam generating units have been operated with availability factors in excess of 90 per cent. If this performance can be matched consistently, there seems to be no reason why one steam generating unit should not supply all of the steam for operating one turbine generator unit. We can then have unit construction, one boiler feed pump, one boiler, one turbine, one condenser, one circulating water pump, and one auxiliary power supply. A reasonable number of cross-connections will insure continuity of service and will reduce the unit cost of spare equipment.

It is also true that this better balance between the size of steam generating units and turbine generator units is desirable irrespective of the operating pressure employed, but the accomplishment of the proper balance will make a greater reduction in the unit cost of the high pressure stations because of the higher unit cost of high pressure boiler plant equipment.

The argument of "the larger the unit, the lower the unit cost" carries throughout the station, for it applies to station structures, piping, and auxiliaries. It likewise applies to transmission lines, substations, and distribution systems right up to the customer's meters. The basic reason for this is the fact that the larger units permit the most economical use of the materials of construction, labor, and supervision.

Construction experience has very definitely shown that the size of the unit has a great deal to do with the comparative cost between high-pressure and moderate pressure installations. Undoubtedly a 5000- kw. 1200-lb. installation would cost more per kilowatt than one for 350 lb., while for much larger units there appears to be little if any difference in unit cost. This is undoubtedly the reason why comparative studies for small plants for industrials usually show that the normal pressure installation is the cheaper, all factors considered.

The recent A. S. M. E. Steam Table Research Committee's publication of the Total Heat Entropy Diagram extended to 3500 lb. per sq. in. and 1000 deg. fahr. total steam temperature has very clearly pointed out that for every steam temperature there is a theoretically economical pressure. The higher the temperature, the higher the economical pressure. For a temperature of 750 deg. fahr. and the regenerative reheat cycle, the economical pressure is in the neighbor-

hood of 1400 lb. per sq. in. In other words, the steam temperature is in reality the governing factor.

Already the Detroit Edison Company has decided to lead the way in an attempt to raise the operating steam temperature to 1000 deg. fahr. They have purchased a turbine generator to operate with steam at moderate pressure at this temperature for their new Delray Station.

As the difficulties with the higher temperatures are worked out, the higher temperatures will be combined with higher pressures and there is a possibility that we will be faced with the necessity of raising operating pressures even higher than 1400 lb.

The development of equipment suitable for utilizing steam at 1000 deg. fahr. will result in justifying the use of higher pressures without reheat, and who can say that with reheat 3200 lb. per sq. in. will not be justified?

If the time comes when pressures considerably in excess of 1400 lb. are justified, we must depart radically from our present designs of boilers. We must abandon thermal circulation in boilers and water-cooled furnace walls and adopt forced circulation. Just because we cannot at once reconcile our minds to such a radical departure in design is no reason for our feeling that there is nothing in the idea before it has been given a thorough trial. Some European engineers believe that forced circulation is advisable for pressures as low as 1500 lb.

The European trend is distinctly toward higher steam temperatures at moderate pressures because the engineers over there believe that the unit cost of high pressure equipment is too great to be justified by the fuel savings to be obtained by its use. On the other hand, in America the trend is just the other way; *i. e.*, higher pressures at moderate temperatures. It is the opinion of American engineers that higher temperatures call for the use of alloy steels and the proper alloys are not available today at prices that make their use profitable.

There is no doubt that many engineers on both sides of the Atlantic Ocean are fully alive to the proper relation between pressures and temperatures, and you can find many instances where certain companies are going far ahead of the general trend. Two noteworthy examples of this are the Detroit Edison Company's purchase of 1000 deg. fahr. equipment, and the recent purchase of a 300,000 lb. per hr., 3200 lb. per sq. in. Benson boiler for the Langerbrugge Station in Belgium.

We have been told on many occasions that the laws of diminishing returns will preclude going much higher in pressures or temperatures, and yet both in America and Europe engineers are going ahead and accomplishing results with higher pressures and temperatures that may force a revision or a reinterpretation of that law of diminishing returns. It is indeed very dangerous to draw definite conclusions from trends; it is wiser to watch the accomplishments of the pioneers.

The experience thus far gained in the construction and operation of high pressure and high temperature stations has very clearly shown that the design and operation calls for engineering talent of the highest type. Designs and construction details must be worked out with the greatest care or otherwise the cost of construction will increase to a point where the fixed charges will offset the savings in fuel. On the other hand, if the proper skill is exercised there does not appear to be any additional capital burden and the greater economy pays a handsome dividend on the effort expended. The argument that greater skill is required is no valid reason for refraining from using the most economical equipment any more than a merchant should refuse to enlarge his business for fear that the larger and more profitable business will require more careful planning and attention.

Construction experience has shown also that high-pressure stations need not be confined to base load operation. Since they can be built for practically the same unit cost as low-pressure stations, they impose no additional capital burden and can be justified for supplying the normal load of the system. This fact will undoubtedly greatly increase the use of higher pressures in the future because it is seldom practical to operate a generating station as a base load station for a long period of years.

Just as the hand-fired grate for large boilers has passed into the discard with the development of efficient automatic fuel burning equipment, so have "rule of thumb" design, construction and operating practises passed on. Brains instead of brawn rule today.

SEEK FOG-PENETRATING LIGHT

There has been a great deal of talk about the fog-penetrating power of the light produced by means of certain lamps, but according to impartial experts on the subject such a source of light is not yet.

Speaking on the subject before the Chicago Section of the Society of Automotive Engineers, R. E. Carlson, of the Westinghouse Lamp Co., said:

"I wish we knew how to design lamps for use in fog. From time to time, particularly in aviation work, one hears about certain wave-lengths of light being more suitable for fog penetration. I have in mind some tests that were well controlled and well conducted by the Bureau of Standards in Massachusetts last year. Those tests showed that, for fog penetration, the difference between a tungsten-filament incandescent lamp and a neon lamp is not great enough to measure within close limits.

"From my own experience, I think the less light one has in a fog the better, because the back glare impairs visibility. On the Pacific Coast, up in Oregon and that region, what are known as 'fog lights' are mounted low so that they reduce, as much as possible, the reflection and back glare. We have no solution for that problem yet; I wish we had."

Electrochemistry and Electrometallurgy

ANNUAL REPORT OF COMMITTEE ON ELECTROCHEMISTRY AND ELECTROMETALLURGY*

To the Board of Directors:

The Committee on Electrochemistry and Electrometallurgy submits the following report covering some of the outstanding matters of interest within the field of the committee. Such a review can never claim to be complete. The past year has brought several items of unusual interest. As an innovation in the report of the committee, for the present year somewhat more details are given about certain materials and their production, including the features likely to be of interest to electrical engineers. For this reason, the number of items covered in the report is somewhat less than in the reports for the several years preceding.

D-C. Supply for Electrolytic Uses

Approximately 200,000-kw. capacity in d-c. machinery is now purchased yearly by growing electrolytic industries throughout the world. Electrolytic processes are essentially d-c. processes requiring large current at relatively low voltage per unit. The problem of a suitable and economical source of power, therefore, is of importance, and one requiring careful study to determine the best conditions in any particular case. The generation of direct current may have some advantages as to cost and maintenance, if the electrolytic plant is not far removed from the source of power, and if exhaust or bled steam can be used to advantage in process work. Such a source of supply, however, is limited in its application and does not permit of interconnection to other sources of power. When power is purchased, the problem of converting it from alternating current to direct current usually arises. Synchronous converters and motor-generator sets both find use for this purpose. Possibly, large mercury rectifiers also may find extended use in the future. In several papers which have recently appeared, it has been pointed out that the proper choice in any particular case must depend, (1) upon voltage and other characteristics of the transmission line; (2) the range of voltage, the current, and other characteristics of the electrolytic circuit; and (3) the efficiency under particular operating conditions; and (4) the initial investment and interest charges. It frequently happens that materials produced by electrochemical means are more costly than similar materials produced without the expenditure of electrical energy; and yet the electrochemical processes are justified by the higher quality of material or by unusual physical or chemical properties. The problem is therefore a complex one which will have much to do with the success or failure of electrolytic production, because the power costs are usually a considerable fraction of the total cost per unit of the material.

Chromium Plating

Chromium plating which was first accomplished 70 years ago has undergone a sensational development in the electroplating field within the past three years. It is only recently that the mechanism of the processes has become sufficiently well understood to make possible its commercial application. From the various uses proposed for chromium plating, it is becoming apparent what may reasonably be expected.

Scratch tests on thin films of chromium indicate that the hardest chromium is harder than any other metals or alloys previously tested; its ductility is almost zero; its expansivity is about the same as for glass or platinum; it resists tarnish to a remarkable degree. The reflecting power of chromium is 65 per cent as compared with silver 95 per cent. Its electrical conductivity is about that of aluminum.

As a protective coating, thin films are desirable. For some purposes 0.00002- to 0.00004-in. are used over a preliminary coat of copper or nickel. Thicker deposits may tend to crack. Chromium deposits are made from a chromic acid bath to which a sulphate has been added. The anodes are of iron or lead. The conditions for making satisfactory deposits are rather critical as to temperature and current density, the latter ranging from 100 to 300 amperes per sq. ft. From the standpoint of the electrical engineer, the large amount of energy required is of interest. The voltage across the tank ranges from 6 to 12 volts. The current must be large and since the valence is 6 and the efficiency of the process low, the amount of metal deposited per coulomb is very small. It has been estimated that chromium plating requires 15 times the electrical energy used for nickel plating in equivalent amounts. However, in the case of chromium but little metal is needed. The process brings with it hazards that require carefully designed ventilating systems to protect the workers. In spite of difficulties which may seem numerous, the desirable properties of chromium as a protective coating, its resistance to wear, its hardness, and its pleasing appearance have brought it into use in many industries. Some of the applications which have been made of it have not been successful; as, for example, in stamping

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dies. The chromium is brittle and flakes off. In the popular, mind chromium is associated with automobile and plumbing fixtures, but in a less conspicuous way, chromium plating has proved its worth by prolonging the life of gages, tapes, measuring devices, forming dies, spinning tools, and printing plates.

An important development during 1928 was the installation of several completely automatic equipments for chromium plating. The electroplating industry has learned the value of chemical control and now it is adding automatic electrical control of current density and control of temperature.

Electroplating of Various Metals

In other fields of electroplating, new finishes have been developed. Cadmium plating, which can be easily done on any commercial metal, promises valuable service as a preventative of rust, but it is handicapped by the high price of metal. A process has long been sought for electroplating aluminum on other metals. A step in this direction has been made in the experimental work of depositing aluminum on other metals from organic solutions. New developments are taking place in the electrodeposition of alloys. Whereas in the past this has been confined chiefly to brass and bronze, today there are a dozen different alloys that may be deposited from aqueous solutions. Nickel-plating continues to increase in spite of the threatened competition of chromium plating. Actually, the latter needs an underlying layer of nickel, and so it has been said that chromium plating has actually stimulated the demand for nickel. The trend in nickel plating is towards the use of very pure anodes containing not less than 99 per cent of nickel.

Hydrogen for Industrial Uses

Industrial uses for hydrogen are rapidly increasing. The electrolytic process is particularly well adapted to the production of hydrogen of a high degree of purity. It is of more than passing interest that a large research laboratory is provided with pure hydrogen piped to the various rooms and consuming in the experimental work more than 2,000,000 cu. ft. of hydrogen per month. In the fat-hardening industries the demand for pure hydrogen is increasing and larger electrolytic cell units in some cases amounting to 4 to 5 times the capacity of present installations are being sought. More electrolytic hydrogen is likewise being used in the synthesis of liquid ammonia, the production of which in 1928 was so large that it became the cheapest alkali per unit. It has been found that liquid ammonia is a very convenient form for transporting hydrogen. Of particular interest to electrical engineers is the use of hydrogen as a cooling agent. It naturally diffuses faster than other gases and has a high thermal conductivity so that it can be used to advantage where it is important to remove heat rapidly. High-speed motors and generators are being operated in hydrogen gas in development tests and a commercial application of hydrogen cooling has recently been made in the case of a large synchronous condenser which is totally enclosed. The capacity of this condenser with hydrogen cooling is said to be 12,500 kv-a., as compared with 10,000 kv-a. if air-cooled. The use of hydrogen for such a purpose is beneficial in other ways, since oxygen and dirt are excluded and the effect of corona on the insulation eliminated. As a safeguard, the pressure of hydrogen is maintained above atmospheric pressure and the purity of the gas is continuously recorded. An alarm is sounded if the purity falls below 91 per cent.

Copper

The change in the copper situation during 1928 was sensational. A sluggish market which had persisted for years with comparatively little prospect of marked advancement was transformed by the increasing demand for this metal. Existing stocks were reduced and outlets for even the high-cost copper provided. Copper as a product of electrochemical industry and as a basic material of electrical construction has a double interest for the electrical engineer. Part of the increased use of copper may be attributed to systematic efforts of a research association to extend its uses and part may be attributed to the growth of electrical industry, which is said to consume in one form or another, more than one-half of the total supply. It has been estimated that the mines of the United States will produce over a million tons during the present year and most of this will be used within this country.

Electrolytic Zinc

A large plant has recently been installed in Idaho for the production of electrolytic zinc by the "Tainton-Pring" process. Good deposits of very pure zinc are obtained from the strongly acid solutions. The cathodic current density is about 100 amperes per sq. ft. and the voltage per cell, about 3½ volts. The nominal capacity of the plant is 50 tons of zinc per day, with provision for trebling this output. Direct current of 16,000 amperes at 500 volts is supplied by two synchronous motor-driven generator units. The electrolytic cells are arranged in two groups of 150 cells, connected in series. Each cell contains 20 aluminum cathodes faced by anodes of a lead alloy. By grounding the midpoint of the circuit, the maximum voltage to ground is reduced to 250 volts. The purified zinc sulphate solution is circulated to the cells until 90 per cent of the zinc has been extracted when the solution contains about 28 per cent acid. The deposition process is a continuous one with periodic changes of the electrolyte. The current efficiency of the electrolytic process averages about 85 per cent. The zinc obtained by this process is of high purity and soft.

Nickel

Improved smelting and refining methods have re-

sulted in improving the purity of commercial grades of nickel. Electrolytic nickel, averaging 99.90 per cent or better, is the highest grade produced on a commercial scale. This is especially suited to the production of alloys containing high percentages of nickel. It is available as "electro-squares" in a variety of convenient sizes. The ferro-nickel alloys containing large percentages of nickel are finding increased use in radio transformer cores because of their extraordinary permeability.

Aluminum

Figures have been published to show that the world's production of aluminum has grown from 24,000 tons in 1908, to 214,000 tons in 1927. Aluminum is typically an electrochemical product. At present two great outlets for aluminum and its alloys are in the manufacture of automobiles and aircraft. It is said that more than 30,000,000 aluminum pistons were made in 1928. Aluminum cylinder heads are beginning to appear. Aluminum alloy frames for motor coaches are decreasing the non-profitable load of these bulky machines. Aluminum crank cases and housings are already familiar. Light and strong alloys are necessary for airplane construction. The strength of a variety of these alloys is now very well known. The fire hazard in the airplane has been reduced and quantity production as in the case of automobiles has become possible. A new material called "alclad" which combines the strength of duralumin and the resistance to corrosion of pure aluminum seems destined to become important in many fields. Aluminum which at one time was considered a material chiefly for cooking utensils, has thus found a wider field. Aluminum cooking utensils continue to increase, but as an outlet for this metal, this application is overshadowed by the newer uses in airplanes, automobiles, trucks, railway cars, furniture, roofing, decorative castings, and foil which competes with tin.

Electric Furnaces

In the electric furnace industry there has been a decided increase in the use of the high-frequency furnace. These furnaces, using a motor-generator type of equipment, have entered the field of silver melting, and it is reported that 3.76 kilograms per kw-hr. can be melted with this form of equipment as compared with 2.9 kilograms per kw-hr. for the earlier type operated by an oscillator. The high-frequency furnace is well established in the non-ferrous field, and it seems likely that it will find use in the steel foundry as a convenient means of holding the heat. A large number of electric furnaces, mostly of the resistor type, has been installed for the nitriding processes for steel. A very hard surface is obtained similar to that produced by case hardening but superior in some respects.

Ceramic engineers have accomplished much after years of experimentation and many failures, and have succeeded in introducing the electric furnace into glass and porcelain industries.

In the carbide industries, the desire to increase the unit by increasing the ampere input at 100 to 200 volts has met with difficulties and the electric furnace engineer is confronted with the problem of how to overcome these limits of design without increasing voltage. At 25 to 60 cycles, the present electrical equipment will not permit of commercial operation beyond 3000 amperes per furnace unit.

A number of electric furnace installations has been recorded in different parts of the world for the production of phosphoric acid and potassium phosphate. There is every indication at the present time that the electric furnace will eventually displace the sulphuric acid process in the manufacture of phosphoric acid. A noteworthy event has been commercialization of the electric furnace for smelting zinc from its ore. At one plant a furnace turning out 50 tons of pure spelter per day has been reported.

The largest peace-time electrolytic alkali-chlorine plant has been put in operation in the vicinity of Charleston, West Virginia. This locality is rapidly becoming a center of electrochemical industry.

Batteries

In the battery field, the production of batteries for automobiles has continued to increase, the number produced yearly being variously estimated from 11 to 15 millions. Since the standard specifications were adopted for them several years ago the quality of dry cells has increased and a proposal to materially increase the minimum requirements for the various sizes and kinds is now before the Sectional Committee on Dry Cells. The dry-cell industry has felt the inroads of the a-c. radio sets, but it is likely that a large number of battery sets will continue to be used. In the field of small rectifiers, the most important development has been the copper-copper oxide type which has displaced many of the electrolytic types.

Electrochemical Research

Interesting results are being obtained in the study of the nature of conduction found in dielectrics and particularly in insulating oils. This field of research requires a knowledge of both electrical and chemical processes. Relationships have been found between the variation of conductivity with time, the accumulation of space charges, and the final dissymmetry of the potential gradient.

A new material of extreme hardness for machine cutting tools has been placed on the market under the name of "carboloy." It consists of tungsten carbide and cobalt. The carbide is extremely hard and the cobalt increases the strength.

The demands of industry for new and pure materials has encouraged the development of electrical processes. Rare metals have been produced by electrolytic methods

and these are gradually coming into the field of technology. We can not anticipate the uses that they may ultimately find in the service of mankind, but the experience with others which we now regard as common indicates that uses rapidly arise when such materials become available commercially. The further purification of the more common metals and the elimination of almost the last fractional percent of the impurities has revealed surprising changes in their mechanical and chemical properties. Electric furnace products bear the brand of superior quality and by the use of electric heating many improvements have been made in working conditions.

The Committee wishes again to acknowledge the helpful cooperation of Professor Colin G. Fink, Secretary of the American Electrochemical Society.

An Economic Study of an Electrical Distributing Station

BY W. G. KELLEY[1]

Fellow, A. I. E. E.

Synopsis.—This paper outlines some of the physical reasons and economic advantages influencing the establishment of Washington Park Distributing Station of the Commonwealth Edison Company of Chicago.

This station is located at the electrical center of the load which it supplies. It receives energy at 66 kv. from an outlying generating station, State Line Station. The voltage is reduced at the distributing station and fed to a number of substations at 12 kv.

The past practise of this company has been to feed the substations at 12 kv. directly from generating stations. However, a study indicated several reasons for discarding the practise in this case.

The main physical reasons were the congested condition in the underground cable system surrounding Calumet Generating Station and the distance from Calumet Station to its dependent substations.

The economic advantages consisted primarily of the decrease in transmission line costs due to the location of the distributing station at the center of the zone load and the savings resulting from the use of 66-kv. instead of 12-kv. for the primary transmission system.

THE subject matter contained in this paper is confined to a study of the transmission costs incident to the establishment of the Washington Park Distributing Station of the Commonwealth Edison Company of Chicago.

A distributing station differs from a generating station in that it receives electrical energy over transmission lines instead of producing the energy by means of generators. The energy is usually transmitted to the station at a higher voltage and distributed from the station at a lesser voltage to a number of adjacent substations.

The three-phase electrical system supplying energy to the distributing station may be termed the primary transmission system and consists in this case of three single-conductor 750,000-cm., 66-kv. cables. The three-phase system conveying energy from the distributing station to the substations may be termed the secondary transmission system, and the feeders are in this case three-conductor, 500,000-cm., 12-kv. cables.

A map of the City of Chicago, showing the various generating stations, Washington Park Distributing Station, and the substations receiving energy from the distributing and generating stations is given in Fig. 1. The various zones or districts fed by the generating and distributing stations are also outlined on the map. As the generating stations must be located on property accessible to water for condensing purposes, they can seldom be located at the electrical center of load for their respective zones.

Table I and Fig. 2 show the load in kilowatts for the various station zones from the years 1920 to 1928, inclusive.

In the case of Calumet and Fisk-Quarry Stations, the zone loads now exceed the generating capacity and part of the energy is supplied to these two zones from State Line Generating Station by means of 66-kv. underground transmission lines.

The distribution of energy in the Calumet Station zone has introduced certain physical and economic difficulties; first, due to the high cable temperatures in the underground conduit system resulting from the large number of heavily loaded cables radiating to the west and north of the station; and second, due to the length of the 12-kv. secondary transmission lines from Calumet Station to the various substations in the zone.

The number of 12-kv. underground cables at Calumet Station is designated by the figures shown on the conduit line in Fig. 3.

Due to the fact that a considerable portion of the zone load is brought into the district at 66 kv. and not generated at Calumet Station, it was proposed that a new station be established at the electrical load center of the northern half of the Calumet zone for the purpose of receiving energy from State Line Station at 66 kv. and distributing it to the various substations at 12 kv.

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TABLE I

GROWTH OF 60-CYCLE ZONE LOAD AT TIME OF SYSTEM MAXIMUM

	1920 Kw.	1921 Kw.	1922 Kw.	1923 Kw.	1924 Kw.	1925 Kw.	1926 Kw.	1927 Kw.	1928 Kw.
Northwest	50,000	65,000	81,430	91,000	84,780	101,850	118,210	128,922	143,260
Fisk-Quarry	140,000	122,000	155,200	91,980	112,985	136,276	140,220	190,840	177,723
Crawford				53,920	80,350	103,019	158,020	177,932	218,777
Washington Park									55,388
Calumet		26,000	38,770	91,290	101,187	141,885	159,000	172,952	123,880
Total	190,000	213,000	275,400	328,190	379,302	483,030	575,450	670,646	719,028

A preliminary study of the secondary transmission cables on the 12-kv. system expressed in circular-mil-feet per kilowatt, showed that a 10 per cent reduction in this ratio could be effected for the entire Chicago area by the establishment of Washington Park Distributing Station.

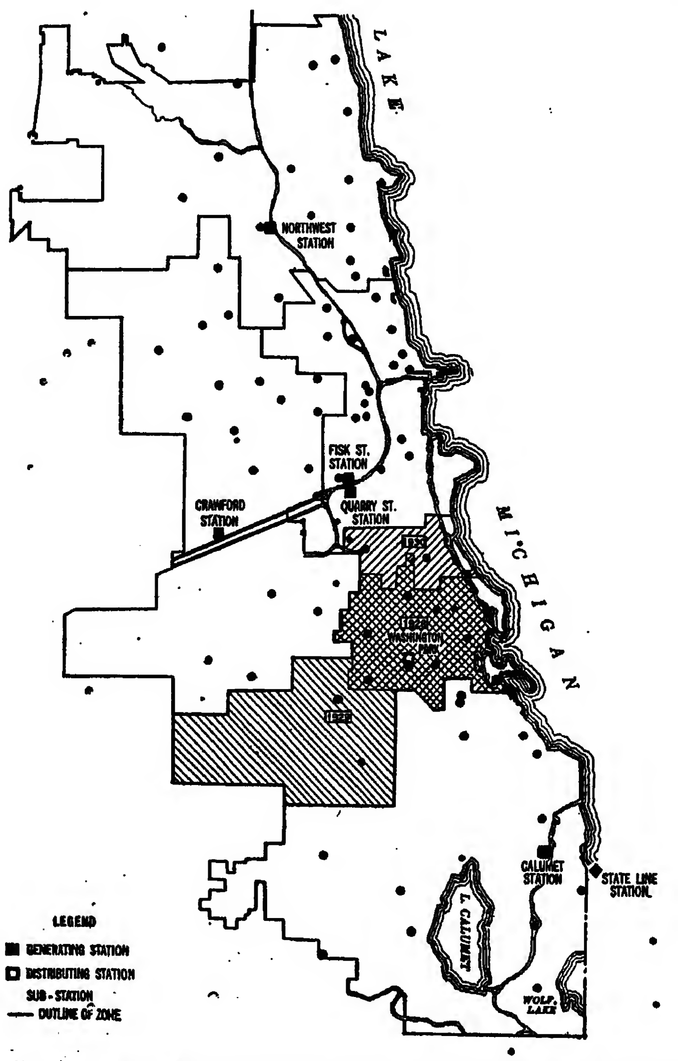

FIG. 1—MAP OF CHICAGO SHOWING THE LOCATION OF STATIONS AND SUBSTATIONS

Eight substations were tentatively selected to form a zone load for the first year for Washington Park Distributing Station and for the year 1928, the load in this zone was 55,388 kw.

Table III shows the load on the eight substations

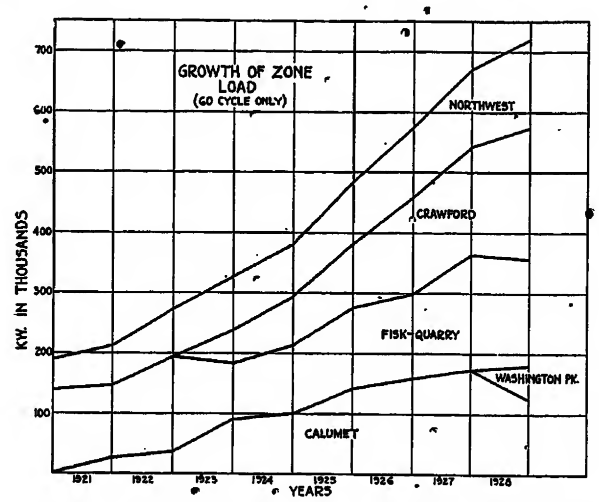

FIG. 2—GROWTH OF ZONE LOAD FOR THE YEARS 1920 TO 1928, INCLUSIVE

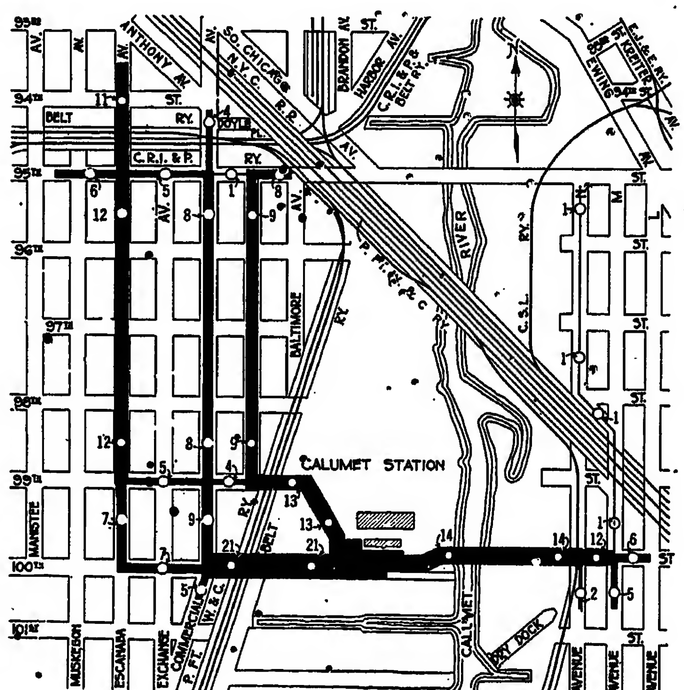

FIG. 3—DIAGRAM OF UNDERGROUND TRANSMISSION CABLES AT CALUMET STATION

The numerals denote the number of three-phase 12-kv. cables in each conduit line

selected for the years 1923 to 1928, inclusive, segregated under the three headings, four-kv., railway, and industrial load.

The average distance from these substations to Calumet Generating Station, weighted for load, was found to be 41,600 ft., while the average distance to Washington Park Distributing Station, weighted for load, was found to be only 8690 ft. This represented a marked decrease in the amount of cable necessary, and formed one of the main economic factors leading to the construction of Washington Park Distributing Station.

TABLE II

TRANSMISSION COPPER IN 12-KV. DIRECT TRANSMISSION LINES

	Length circuit feet	Copper Volume 1,000,000 cir. mil. ft. (one phase)	Peak load	1,000,000 cir. mil. ft. per kilowatt
1923	1,961,882	728,885	328,100	2.22
1924	2,202,563	980,044	379,302	2.58
1925	2,376,517	1,079,283	483,030	2.23
1926	2,887,780	1,352,029	575,450	2.35
1927	3,183,648	1,505,647	670,646	2.24
1928	3,118,895	1,483,448	719,028	2.06

TABLE III

GROWTH OF PROPOSED WASHINGTON PARK ZONE LOAD

	1923	1924	1925	1926	1927	1928
Hyde Pk.	11,600	10,400	9,880	8,900	7,430	8,100
Prairie	5,180	4,920	5,890	5,630	4,900	5,740
62nd St	9,100	7,820	8,825	9,270	9,400	10,200
Harper		3,660	4,450	4,300	5,300	5,210
56th St	10,720	9,320	9,600	9,650	7,560	7,350
Lowe	760	3,100	4,530	3,950	6,360	7,400
Total 4-kv	37,360	39,220	43,175	41,700	40,950	44,000
62nd Railway	5,760	5,520	4,140	4,130	4,070	4,058
E. 63rd Railway			1,970	2,670	4,000	3,370
Total Railway	5,760	5,520	6,110	6,800	8,070	7,428
Hyde Pk. Indus			22	655	416	104
62nd Indus			149	663	445	1,573
56th Indus			307	436	1,148	1,460
Wash. Pk. Indus				457	725	328
Total Indus			478	2,211	2,734	3,460
Grand Total	43,120	44,740	49,763	50,711	51,754	54,888

The following cost data were used in making the study:

12-kv. three-conductor cable......$1.95 per ft.
66-kv. single-conductor cable.. 2.64 to 3.07 per ft.
Conduit per duct............ 1.00 per ft.

Due to the fact that the energy for this zone is brought to it at 66 kv., it would have been necessary to install switching equipment, transformers, and the necessary buildings either at Calumet or Washington Park Stations, and the cost of these was assumed to be the same whether installed at one point or the other.

The cost per kilowatt of the 66-kv. primary transmission lines, with the necessary conduit from Calumet Station to Washington Park Distributing Station, was $11.40, and the total cost allocated to the Washington Park Distributing Station plan, based on the load of 55,388 kw., was therefore $630,000. The cost of 12-kv. secondary transmission lines and conduit from Washington Park Distributing Station to the eight substations, was $220,000, making a total cost for this plan, of $850,000.

The cost of 12-kv. secondary transmission lines and conduit from Calumet Station to the various substations, assuming Washington Park is not to be built, was found to be $994,000, making a difference of $144,000 capital investment in favor of the construction of Washington Park Distributing Station.

This saving is due primarily to the development of 66-kv. underground cable and the greater economy of transmission at this voltage over the use of 12-kv. cable.

It is proposed to put additional substations as shown in Fig. 1 in the Washington Park Distributing Station zone during the years 1929 and 1930, thereby increasing the zone load, and also to establish additional distributing stations in the central and northern sections of the city, when economic conditions warrant.

ATOMS NOT LIKE SOLAR SYSTEMS

As every modern school child knows, the atoms of matter which were thought indivisible even 30 years ago are now considered to be complicated agglomerations of positively charged protons and negative electrons. But the manner in which the structure of the atom is visualized has changed vastly during the past few years. The modern physicist has discarded the entire picture-theory of imagining the atom as a small replica of the solar system.

These facts were stated at a recent meeting of the Detroit Section of the Society of Automotive Engineers by Professor Vladimir Karapetoff, of Cornell University, who pointed out that when physicists endowed an atom with the central nucleus and imagined electrons like little spheres revolving around that central nucleus, what they did was not different in principle from the process whereby the primitive man creates his god in his own likeness. They knew the solar system was so made, so they put it in the atom. This method worked well enough for hydrogen, composed of only one nucleus and one electron; but the complexity of the atoms of the very heavy chemical elements spelled the death knell of the picture theory of the atom and the attempts to express the motion of approximately 92 electrons by equations and to solve these equations.

Abridgment of

Current Transformer Excitation Under Transit Conditions

BY D. E. MARSHALL* and P. O. LANGGUTH*

Associate, A. I. E. E. Associate, A. I. E. E.

Synopsis.—Tests of circuit breakers, relays, and similar devices in which current transformers have been used to step down the large currents involved to values measurable by the oscillograph, have shown peculiar errors in the records during the transient portion of the current wave.

The purpose of this paper is to show that the abnormal excitation of the magnetic circuit of the current transformer required during transient conditions is the cause of these errors, and to point out how the errors may be minimized sufficiently to be negligible.

Mathematical expressions are also derived to make it possible to predetermine the ability of a transformer to handle transients correctly and to be a guide in the design of transformers for this service.

* * * * * *

THIS paper is closely related to the problem of the measurement of transient alternating currents. When certain apparatus such as circuit breakers are subject to short-circuit tests, it is desirable to have a correct indication of current during the transient condition.

In the past, two methods have been used for measuring heavy transient currents; namely, the non-inductive shunt and the current transformer. Considerable field testing has demonstrated that these methods have introduced difficulty under some conditions. When the shunt is used, it is of course necessary to insulate it and associated oscillograph apparatus from ground to the extent of full-line voltage. Furthermore, non-inductive shunts can be used only with non-inductive measuring devices and therefore cannot be used with the current coil of watt oscillograph elements, which are highly inductive, for the measurement of instantaneous power.

Even with resistive burdens inaccuracies will result due both to self-inductance and mutual inductance on multi-phase set-ups.

The use of the current transformer for the measurement of transients under certain conditions has resulted in some inaccuracies. In this paper effort has been made to determine the causes of the errors which occur, the extent of the errors, and means for elimination or minimization. The causes of the errors are first briefly outlined. A discussion of the practical importance of the errors is given as is also mathematical expositon of the theory including the formulas for designing transformers having suitable characteristics for the measurement of transients. A number of oscillograph records amplifying and checking the theory is presented; and finally a method is given for testing transformers to determine their suitability for use under transient conditions.

The authors are indebted to Mr. J. F. Peters for constructive criticism, and to Mr. L. R. Smith for assistance in conducting the tests.

Outline of Causes of Errors and Their Characteristics

If the circuit in which the primary of the current transformer is connected contains both resistance and inductance, the current flowing in that circuit just after its switch is closed will not assume always immediately a pure sinusoidal wave form, but will be dis-

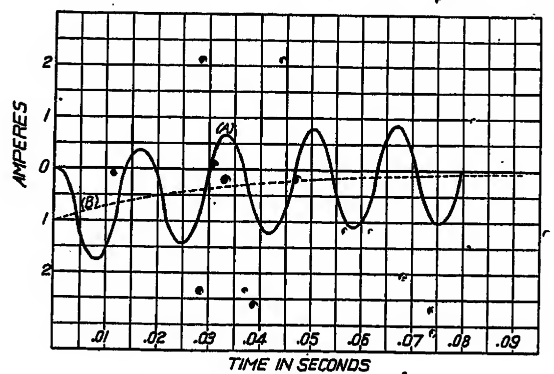

Fig. 1—Transient Current for Inductive Circuit Having Time Constant 0.0304 at 60 Cycles

(A) = Asymmetrical current wave

(B) = Displaced zero axis

placed from its normal zero axis in a manner similar to the current curve shown in Fig. 1. (Eq. (4) of complete paper.)

This asymmetry rapidly decreases and in practical circuits disappears in about 3 to 15 cycles of 60-cycle current. The degree of asymmetry depends on the point of the voltage wave at which the switch is closed. The current wave is practically normal if the switch is closed when the voltage is at its maximum and may be entirely above or below the zero line, if the switch is closed at the zero of the voltage wave. The point on the voltage wave at which the switch is closed is usually a matter of chance, although it is sometimes argued that inasmuch as in high-voltage circuits the current might start before the switch is completely closed, the first case is the more probable. Thus in the majority of

*Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Presented at the Regional Meeting of the Middle Eastern District of the A. I. E. E., Cincinnati, Ohio, March 20-22, 1929. Complete copy upon request.

cases, the transient will be comparatively slight. (Fig. 1 is calculated on the basis of a closure under the worst possible conditions.)

The important thing to appreciate, so far as this paper is concerned, is that this dissymmetry is quite likely to occur just after the switch is closed. The paper therefore treats of the effect of the dissymmetry on the magnetizing current and the resultant error in a current transformer under such transient conditions.

The error is due to the over-saturation of the transformer which is caused by the d-c. component of the asymmetrical current. This condition is of course aggravated if the secondary burden is excessive. The error in transformation also will vary depending upon the amount of residual magnetism and its polarity with respect to that of the d-c. component. For this reason, in tests where accuracy is essential, the transformer selected for use in measuring transients must be designed for a low degree of saturation at the burden to be imposed, and must be demagnetized between successive heavy shots. On tests which do not come up to the knee of the saturation curve, the residual will probably be so slight that demagnetization will not be required.

A complete mathematical exposition is included in this paper and will be printed in full in the TRANSACTIONS. The equations and the data indicate that the inaccuracies of the current transformer during unsymmetrical transients are caused by the large flux required to generate the voltage necessary to reproduce the transient in the burden of the transformer. The maximum value of transient flux is dependent upon the magnitude of the current, the duration of the transient, the design of the transformer, and the secondary burden.

A series of tests was made to check and amplify the mathematical theory and the data thus secured are given under the heading of Test Data in this paper.

PRACTICAL IMPORTANCE OF ERRORS

As these errors are caused by the dissymmetry of the primary current which is dependent on the cyclic time of closing the switch, their appearance is rather uncertain, but always possible, and may cause erroneous conclusions on an important test.

The magnitude of these errors is generally comparatively slight, although on extremely heavy short circuits of a high degree of asymmetry, with a particularly unsuitable transformer having a heavy secondary burden, the degree of over-saturation may be so great as to cause an error of, roughly, 50 per cent in the r. m. s. value of the first current wave. The most noticeable effect of the errors is the distortion of the secondary current wave shape rather than serious diminution of the crest value.

In most cases the error thus introduced is comparatively unimportant except in the cases of high-speed relay operation and watt oscillographs. The great majority of tests to determine rupturing capacity of circuit breakers are so made that the current has reached a steady-state condition before arcing starts. Even though this condition has not been reached, the r. m. s. current of the first half cycle of arcing is usually determined from the crest value, with due allowance for the displacement of the neutral axis, on the assumption that the wave is of sinusoidal shape which partially corrects for the error but always indicates a lower current than actually occurred.

In oscillograph testing, however, the accuracy required is not of so high an order as required for current transformers used with watthour meters; hence the allowable flux density is higher. The oscillograph burden is lower than the usual burdens. These two factors tend to compensate for the high value of transient flux required, thus making the problem of applying or designing a suitable current transformer less difficult than might appear.

The only competitor of the current transformer has been the non-inductive shunt. This method, however, presents difficult insulation problems, as the oscillograph elements must be directly connected to the high-voltage lines.[1] It should also be fully appreciated that a non-inductive shunt is only allowable for use with non-inductive burdens. It must always be of the same time constant as the burden. This effect is not serious for straight current-measuring oscillograph elements. Watt oscillograph elements, however, having current coils of relatively high inductance, cannot be used with non-inductive shunts.

The current transformer works better, if anything, for inductive than for resistive burdens, and may be used for any type of element. Against the disadvantages of demagnetizing transformers may be set the added safety to operators, the lack of necessity of insulating the operator and instrument from ground, and the possibility of using the transformers supplied in the apparatus under test instead of special equipment.

MATHEMATICAL EXPOSITION

If the primary current is unsymmetrical, it may be represented by the following equation as given earlier in the paper: (See Fig. 1.)

$$i = I\left[\sin(\omega t + \alpha) - \sin\alpha\, \epsilon^{\frac{-t}{T}}\right]$$

If this expression is substituted in (15) the equation for the magnetizing current will be found to be:

$$i_1 = I\left\{\frac{\sqrt{R_2^2 + \omega^2 L_2^2}}{R_2\sqrt{1 + \omega^2 T_1^2}}\left[\sin(\omega t + \alpha + \phi - \Delta) - \sin(\alpha + \phi - \Delta)\,\epsilon^{\frac{-t}{T}}\right] + \frac{L_2 - R_2 T}{R_2 (T - T_1)}\sin\alpha\left(\epsilon^{\frac{-t}{T}} - \epsilon^{\frac{-t}{T_1}}\right)\right\}$$

$$T_1 = \frac{L_1 + L_2}{R_2};\ \tan\phi = \frac{\omega L_2}{R_2};\ \tan\Delta = T_1\,\omega;\ (i_1 = 0),\ (t = 0). \qquad (16)$$

1. For references see Bibliography.

If we substitute in Equation (16), $L_2 = 0$, $\sin \alpha = 1$, which causes maximum primary transient), we have:

$$i_1 = I\left[\frac{1}{\sqrt{1 + \omega^2 T_1^2}}\cos(\omega t - \tan^{-1} \omega T_1) - \frac{T}{T - T_1}\left(\epsilon^{\frac{-t}{T}} - \epsilon^{\frac{-t}{T_1}}\right) + \frac{\epsilon^{\frac{-t}{T_1}}}{1 + \omega^2 T_1^2}\right] \qquad (18)$$

which gives the shape of the magnetizing current as a function of $(T_1) = \frac{L_1}{R_2}$. This factor is easily calculated from the magnetizing current—voltage characteristic of the transformer, and the total secondary resistance.

Maximum Value of Transient Flux. As given before, the transient term may be represented by Equation (17):

$$A\,\epsilon^{\frac{-t}{T}} - (A + B)\,\epsilon^{\frac{-t}{T_1}} = u$$

where u represents the transient portion of the magnetizing current. Differentiating (17) and equating to zero, we find that

$$t = \log_e \left[\frac{T_1}{T}\,\frac{A}{A + B}\right]^{\frac{T\,T_1}{T_1 - T}} \qquad (19)$$

which is the time at which the transient term reaches its maximum value.

Substituting this expression in Equation (17), we have for the maximum value of the transient magnetizing current:

$$U_{max} = A\left[\frac{T_1}{T}\,\frac{A}{A + B}\right]^{\frac{-T_1}{T_1 - T}} - (A + B)\left[\frac{T_1}{T}\,\frac{A}{A + B}\right]^{\frac{-T}{T_1 - T}} \qquad (20)$$

By substituting the values of the constants of Equation (17) in the above Equation (20), the correct maximum value of the transient magnetizing current will be obtained.

For design purposes Equation (18) is accurate to a high degree. By taking the coefficients as given there and substituting in (20), and by the use of a justifiable assumption, the following simpler equation for the maximum is derived:

$$U_{max} = I\left(\frac{T_1}{T}\right)^{\frac{-T_1}{T_1 - T}} \qquad (21)$$

where as before,

$T_1 = \frac{L_1}{R_2}$, T = time constant of primary transient,

and I = maximum value of the steady-state primary current.

Test Data

As a check on the theory, a series of tests was made on several through type current transformers. For the purpose of separating the exciting current component from the primary current, a scheme shown in Fig. 10 was used. A primary circuit was set up to have definite pre-determined values of resistance and inductance such that transients of definitely known time constant (T) could be obtained. To obtain the total secondary current and the total primary current, non-inductive shunts were used in parallel with the oscillograph elements V_1 and V_3. A combination of three shunts of equal value was used in the differential circuit with oscillograph element V_2 for the purpose of obtaining the difference between the primary and

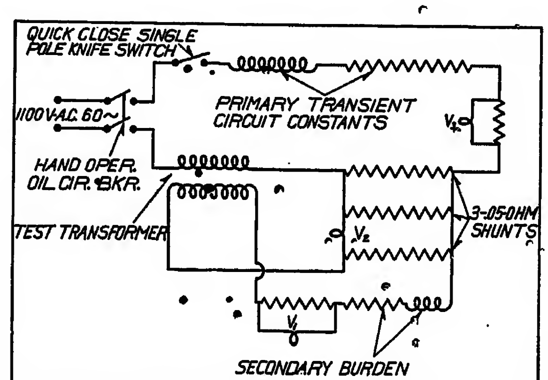

FIG. 10—SCHEMATIC DIAGRAM OF TRANSIENT TESTING CIRCUIT

secondary currents. As the ratio of the transformer is 2 to 1, and as the resistance of element V_2 is high in comparison with the resistance of the shunts, the deflection of the element V_2 will be proportional to the difference between the primary and secondary currents, thus giving a measure of the exciting current or instantaneous error of the transformer.

The transformer used for these tests was of ring type, constructed to fit the standard 37,000-volt condenser type bushing having design constants

a. Secondary turns.................100
b. Core diameter inside...............4⅜ in.
c. Core diameter outside.............6⅛ in.
d. Core cross sectional area...........4.26 sq. in.
e. Secondary resistance...............0.1668 ohms.
f. Saturation characteristic (referred to secondary).

Amperes	Volts
0.2	32
0.5	73
1.0	90
2.0	99
8.0	112

By short-circuit impedance test of the transformer with wound primary, it was determined that the leakage inductance of both primary and secondary is exceedingly small, (power factor 99 per cent), thus justifying the assumption made in the theory of zero leakage inductance.

To allow the use of the measuring scheme of Fig. 10, it was found necessary to use relatively low values of current. Thus, to simulate the actual transformer performance under heavy short circuits, it was necessary to wind a primary of 50 symmetrically spaced turns on the transformer, thus giving the effect of 800 amperes, (800 ampere-turns).

Numerous tests were made under various conditions of circuits and transformer.

The results of a few of the tests and their analysis are given individually in the form of oscillograms.

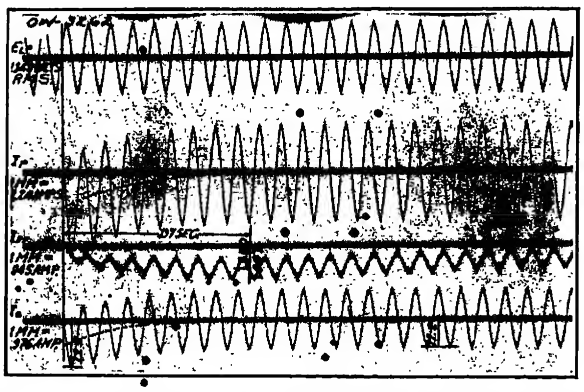

Fig. 12—Oscillogram of OC Transient with Oscillograph and Shunt Burden

The oscillogram, Fig. 12, was taken with the transformer thoroughly demagnetized, and approaches closer to the theoretical curves than any of the oscillograms. The primary current is identified as I_p, the secondary by I_s, and the differential or exciting current by I_{df}. The transient portion of the magnetizing current is well above the zero line. This current gradually dies down to a steady state of very small amplitude symmetrical with respect to the zero line. This film should be compared with Figs. 1, 5, and 6 of the complete paper.

The power factor of the primary circuit is 5.77 per cent, which corresponds to a time constant (T) of 0.0447. The total secondary circuit resistance including oscillograph shunts is 0.30. Since the exciting current of the transformer is one ampere at 90 volts on the "knee" of the saturation curve, we can determine that the average value of (T_1) in Equation (18) is 0.795.

The time at which the transient portion of the magnetizing current should be a maximum is given by Equation (19). Substituting the value of T_1 calculated above, the time obtained is 0.137 seconds. This time is indicated on the film for comparison with the actual maximum as shown on the oscillograph.

The maximum exciting current is given in percentage by the Equation (21), which, calculated for the above constants, is 4.8 per cent. From measurements of the oscillogram, Fig. 12, the secondary current is 11.2 amperes and the maximum transient exciting current is 0.45 ampere, giving a per cent maximum exciting current of 4.02. These values check quite closely when the errors in measurement and oscillograph calibration are taken into account.

Method of Selecting Suitable Transformer

When a current transformer is to be used for short-circuit testing, before making tests, some information should be obtained regarding its adaptability for use on transients. It is a relatively simple matter to test a current transformer to determine its suitability for measuring transients. The first operation necessary is to obtain the saturation curve of the transformer by taking readings of volts and amperes into the secondary with the primary circuit open. Then the resistance of the secondary may be measured with a small testing set, to which should be added the oscillograph shunt resistance. (Designate this sum by R_2.) Using values up to the knee of the saturation curve, divide each voltage by the corresponding current and obtain an average of these results for a value (Z_1). The factor T_1 may be calculated from the following formula:

$$T_1 = \frac{Z_1}{2\,\pi\,f\,R_2}$$

Calculate the time constant (T) of the primary circuit as the ratio of inductance to resistance of the primary circuit. Knowing (T_1) and (T), the ratio of maximum transient exciting current to maximum secondary steady state current can be exterpolated from Fig. 8, or calculated from Equation (21). This ratio gives directly the percentage maximum error due to the transient in instantaneous values of secondary current.

Dividing the r. m. s. exciting current just below saturation as obtained from the saturation curve, by the above ratio, will give the r. m. s. value of steady-state secondary current which the transformer is capable of handling without excessive errors due to saturation under the given transient conditions.

If the percentage error is within the limits of accuracy desired, and if the current to be measured is not greater than the amount calculated above, the transformers hould be satisfactory for use in that transient test. The authors' experience has been that the calibration and measurement of oscillograph films give results of an average accuracy of ±5 per cent. The

transformers should be of about the same order of accuracy.

If transient tests are to be made in fairly close succession, and especially for heavy OCO transients, the transformers should be demagnetized before each test. This is easily done by arranging the current transformer circuits to allow them to be switched easily from the oscillograph elements to a source of alternating current of a value comparable to the saturation current obtained previously. This current should then be reduced smoothly to zero by the use of slide wire resistors or their equivalent. In general, if the source of power is 110 volts, two resistances will be required in series; one of the magnitude of 0 to 50 ohms and the other from 0 to 500 ohms. The first should be of sufficient capacity for saturation current, and the second should introduce enough resistance to reduce the current to a minimum value for thorough demagnetization.

At first thought, the demagnetizing operation would seem an added burden to the complexities of oscillographic testing. If, however, a source of low-voltage alternating current is available, the arrangement of the demagnetizing circuits adds but little to the set-up, and its use becomes a small matter of extra routine on the part of the oscillograph operators.

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Transportation

ANNUAL REPORT OF COMMITTEE ON TRANSPORTATION*

To the Board of Directors:

Following established precedent, your Committee submits a brief review of the year's development in the application of electricity to transportation.

Steam Railroad Electrification

Pennsylvania Railroad. The Pennsylvania Railroad has completed the electrification of its suburban service from Philadelphia to Wilmington, Delaware, on its main line to Washington, and to West Chester, Pa., on the Wawa Branch. The 11,000-volt, 25-cycle, single-phase system with overhead catenary used is in accordance with the original electrification work on the Pennsylvania in the vicinity of Philadelphia.

Of far greater importance, however, is the announced program and actual starting of work on the electrification of the entire road train service, freight and passenger, between New York and Wilmington, Delaware.

The project covers the passenger and freight service on 325 mi. of line and 1300 mi. of track, beginning at Hell Gate Bridge, New York, where connection is made with New England, and extending west and south to Wilmington, west from Philadelphia on the Main Line in the direction of Harrisburg as far as Atglen, and the low grade freight lines which join at Columbia, Pennsylvania, and connect the cities of New York, Philadelphia, and Wilmington with the West.

Work is already under way on the 132,000-volt tranmission line through Philadelphia for the extension to Trenton.

Great Northern Railway. The Great Northern Railway has completed and placed in service the extension of the present single-phase electrification through the new tunnel from Scenic to Berne and then east to Wenatchee. This required the abandonment of its old line from Scenic to Cascade through the snow sheds, which electrification was completed about two years ago.

All traffic is now handled between Wenatchee and Skykomish with motor-generator locomotives having d-c. traction motors, the overhead contact system supplying energy at 11,000 volts, 25 cycles, single-phase.

Boston, Revere Beach & Lynn Railroad. This narrow gage line has completed its electrification of 15 route miles, using 600-volt d-c. overhead catenary system with multiple-unit operation.

Cleveland Union Terminal Company. In connection with the building of a combined terminal station and office building in the heart of the business district of Cleveland, it is necessary to handle all trains electrically. Through passenger trains of the New York Central, C. C. C. & St. L., and N. Y. C. & St. L. will be so handled through the city. It has been decided to use 3000 volts direct current with overhead catenary system. Twenty-five 204-ton passenger locomotives, with a rating of about 3000 hp. each, have been ordered and active work on substations and distribution system

*Committee on Transportation:
W. M. Vandersluis Chairman,
R. Beeuwkes, A. E. Bettis, J. V. B. Duer, Horace H. Field, E. R. Hill, W. K. Howe, D. C. Jackson, John Murphy, W. S. Murray, W. B. Potter, Ralph H. Rice, N. W. Storer, Richard H. Wheeler, Sidney Withington,

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started. Power will be purchased from the local power company.

Interurban and suburban trains will also use the station over separate tracks with 600-volt d-c. overhead trolley construction.

Reading Company. The Reading Company has started construction on the Philadelphia Suburban Electrification, which, initially, will include multiple-unit service from the terminal in Philadelphia to Chestnut Hill, Lansdale on the Bethlehem Branch, Hatboro on the New Hope Branch, and Langhorne on the New York Branch. This electrification was decided on not to meet any particular operating difficulty or municipal requirements, but to furnish a better service at a lower operating cost and with a hoped for increase in traffic and revenue.

The initial installation will consist of 50 route miles and 110 track miles, and the 11,000-volt, 25-cycle, single-phase system will be used.

Delaware, Lackawanna & Western Railroad. This company is actively engaged on the design and construction work covering the electrification of its suburban service with multiple-unit car trains from its Hoboken terminal to Dover, New Jersey, via Morristown; also the Montclair Branch and the Passaic & Delaware Branch. The running tracks between West End Junction and Kingsland are included in the program, as the inspection and repair facilities are to be located at the latter point. Certain freight movements between Secaucus and Hoboken Yards will be made electrically.

Power will be supplied through five substations at 3000 volts, direct current, to the catenary system. The program calls for the electrification of 150 track mi. of main line and 25 mi. of yards and sidings.

City of Rochester. The city of Rochester has completed and put in service an electrified railroad through the city, in the bed of the old Erie Canal, the right of way being purchased from the State. A modern boulevard has been built over the tracks for a considerable distance in the heart of the city.

The line is nine miles in length with two tracks the full distance, one additional freight track for seven miles, and two other freight tracks for 1½ miles. Interchange tracks with steam railroads are provided. Frequent rapid transit cars are operated.

The overhead construction is of the catenary type using three wires with one contact wire. Inclined catenary is used on all curves except the slight ones at station approaches. Operation is at 600 volts direct current.

Diesel-Electric Locomotives

The development of oil-electric locomotives using prime movers of the Diesel type is continuing. A 300-hp. prime mover is most in use to date, one manufacturer having delivered 25 locomotives weighing about 60 tons each, equipped with one 300-hp. Diesel engine with generator and d-c. traction motors.

Eight locomotives with the same type of power plant, but in duplicate, (the locomotive weighing about 108 tons), are also in service. This is in addition to the New York Central combination third rail, overhead, and storage battery locomotive equipped with the same type of 300-hp. Diesel engine with generator for operation off the trolley or third rail and for charging the battery.

The New York Central has recently accepted delivery of a Diesel-electric locomotive for passenger service on its Putnam division. The engine is a four-cycle air-injection Diesel of the 12-cylinder V-type with a full-load rating of 900 b. hp. On the same division is also a freight locomotive with a six-cylinder 750-hp. solid-injection Diesel. Electrical equipment covers a main generator and an auxiliary generator direct-connected to the engine, four d-c. traction motors, control equipment air compressors, and auxiliaries.

Another manufacturer has supplied the Long Island R. R. with an articulated locomotive for switching purposes, equipped with two 330-hp. Diesel engines and electrical equipment. The complete locomotive weighs 87 tons.

The largest single-unit Diesel-electric locomotive built so far, however, is that purchased by the Canadian National Railways. It consists of two separate cabs, each cab containing a 12-cylinder Diesel engine of the solid-injection type rated at 1330 hp. at 800 rev. per min. Each unit weighs 325,000 lb., of which 240,000 lb. are on driving wheels. The present gear ratio was laid out for high-speed passenger service.

Other experimental oil-electric locomotives of varied horsepower are in process of development.

General Purpose Locomotive

The Commonwealth Edison Company has ordered for trial what might be called a General Purpose Locomotive. It will weigh 85 tons with all weight on drivers and is intended primarily for switching work. It can operate directly from the overhead at 1500, 750, or lower voltage. A storage battery having a capacity of 544 ampere-hours at the six-hour rate is provided, this battery to be charged through a motor-generator set when operating under the wire, or from two 155-hp. gasoline engines driving generators. The engines can be operated with distillate fuel. The four motors are rated at 250 hp. each, at 750 volts, one-hour rating. This locomotive will be put in switching service on the Illinois Central Railroad in the near future, for trial.

Rail Cars. Diesel-Electric

The Canadian National Railways has in service 14 Diesel-electric rail cars, four, six, and eight cylinders each, with a rating of from 200 to 400 hp. They are continuing the use of the Diesel type of motive power rail

cars and now have on order nine cars to be equipped with six-cylinder engines, rated at 400 hp., each at 900 rev. per min.

Gasoline-Electric

Over 120 gasoline-electric rail cars primarily for branch line service were put in service during the past year.

They vary in weight, and also in power from 200 to 800 hp. in one- two- and three-unit power plants with individual engines rated up to 400 hp. The majority have single power plants with engines of from 275 to 400 hp., the tendency in the last year being toward the larger units. One company is putting out power plants of 135 hp. each, one, two, or three being used, depending upon the weight of a car and the desired trailer load. The largest cars have two of the 400-hp. power plants and are in service on the Chicago, Rock Island, and Pacific Railway.

Marine Propulsion

The electric-drive airplane carriers *Saratoga* and *Lexington* broke all existing speed records for capital naval ships in their sea trials.

The use of turbine-electric drives for large ships and Diesel-electric drive for smaller ships, ferries, and tugs continues to grow.

Car Retarders

Refinements have been made in the design of both electro-pneumatic and straight electric car retarders for regulating the speed of cars being operated over humps to classification tracks.

Where formerly all switches were controlled from one central point by electropneumatic or electric switch machines and where each cut of cars was accompanied by a car rider to control the speed of the cut, now a large yard may be handled from separate towers near the switches, each tower controlling a group of switches and retarders with car riders eliminated. Several such yards are in successful operation.

Radio Communication

Several installations of radio communication between locomotive, caboose, and station have been in successful operation. Apparatus as mentioned above is now available for radio communication between trains and between hump engines and the various control towers.

Centralized or Dispatchers Control

The railroads are making great strides in the movement of trains by signal indication only and have made use of the recent developments in centralized or dispatchers control for this purpose.

It is now possible and practicable to control electrically from a central point all desired switches and signals over a considerable route mileage. This arrangement facilitates meeting and passing points and thereby decreases running times between terminals with consequent savings.

Between Stanley and Berwick, Ohio, on the New York Central Railroad, the principal switches, some 30 in number, with all signals, are controlled from one point. This covers 37 mi. of single track and three of double track.

There are over 20 installations of varying lengths in service or on order, and the use of this scheme is growing rapidly.

Train Control

Covering the installation of train control on some 44 Class 1 railroads, the orders of the Interstate Commerce Commission have been complied with and there are now over 15,000 track mi. and about 9000 locomotives equipped. In addition, there have been voluntary installations covering over 3000 road miles and over 750 engines.

The installations cover continuous control, intermittent control, and speed control.

While no new orders of the Interstate Commerce Commission are contemplated, yet the Division of Safety is following up the whole subject and suggesting further installations where, in their opinion, conditions warrant them.

Supervisory Control

The use of supervisory control in the handling of substation and switching station apparatus has continued. The last year has seen considerable development work done on the so-called synchronous selector and relay types, with initial installation of the first mentioned on the Cincinnati Street Railway System, and of the second at the Grimm Avenue Substation of the Chicago Surface Lines.

Mercury Arc Rectifiers

The use of mercury arc rectifiers has continued rapidly, there now being in the United States in the vicinity of 40 installations for street railway, interurban, and steam road electrifications. These are arranged for manual, semi-automatic, and automatic control. The tendency has been to increase the capacity per bowl, there being one installation by the Commonwealth Edison Company in Chicago, having a capacity of 5000 amperes at 600 volts in one bowl. This is an automatic station for railway use.

High-Speed Circuit Breakers

The high-speed a-c. circuit breakers of both the air and oil type as mentioned in last year's report have been completed and are now in successful operation on the Wilmington and West Chester extension of the Pennsylvania single-phase electrification. These circuit breakers interrupt short circuits in a half cycle or less and are comparable to the high-speed d-c. breakers which have been in use on steam railroad electrification for the last three years.

Abridgment of

Progress in the Study of System Stability

BY I. H. SUMMERS* and J. B. McCLURE*

Member, A. I. E. E. Associate, A. I. E. E.

Synopsis.—In the second part of this paper and in the appendices, attention is given to simplified methods of treating the problem of system stability. Methods which have been found useful in making many system studies are recorded. These methods have had considerable verification by tests both on a model system and on large operating systems and have been simplified to such an extent that many operating companies are now finding it to their advantage to undertake the work of making careful studies of their own systems, just as they now make short-circuit studies which formerly were thought too difficult and too highly theoretical.

The first part of the paper gives some comments and conclusions of the authors and their colleagues as a result of many such system studies as well as studies involving more detailed methods, and also as the result of practical experience through contact with various operating companies. Some of these comments are based directly upon an example which is given in detail in Appendix I.

INTRODUCTION

THE literature on Power System Stability is growing rapidly.† It includes papers on theoretical methods of calculating stability, the observations of actual systems, and on methods of improving stability. This paper is intended to give the conclusions of the authors and their colleagues, based on many careful system studies and observations and tests on actual and model systems.

The conditions under which instability occurs may be classified as,

Case 1. Under steady-load conditions due to inadequate synchronizing power.

Case 2. Under steady-load conditions due to hunting.

Case 3. During disturbances, particularly those due to short circuits.

Case 1. Various criteria have been developed to permit the design of a system which will be stable under these conditions.[1, 15, 21] Continuously vibrating regulators are helpful in increasing the power limit, especially when the machine synchronous reactances are a large percentage of the whole reactance. To allow for some swings and hunting, a power system must be stable under steady-load conditions for a reasonable margin above the expected load; otherwise the system will be liable to lose synchronism at any time. Therefore, no system should be considered practical unless such a margin is established at the outset. Thus, in practise, the problem reduces to the consideration of cases 2 and 3.

Case 2. This type of instability occurs principally at light loads and when the resistance of the lines involved is high. Continuously vibrating regulators are apparently helpful in eliminating danger from this cause.

Case 3. This is the type of instability which demands most attention today. Faults may be conductor-to-ground, conductor-to-conductor, two-conductors-to-ground, or three-conductors, short-circuited in the order of their severity. Experience indicates that some systems are subjected largely to one-conductor-to-ground faults, while others are subjected chiefly to two-conductor-to-ground faults. The character of the fault, whether one-conductor or two-conductor-to-ground, has a decisive influence in the design of systems for stability at all times.

The effect of these faults is to throw an active and reactive load suddenly on the system and to reduce the synchronizing power between machines. As a result, the position of the rotors of the machines in the system tends to vary, the variation being in general such as to increase the angular separation between the generators and motors.

An accurate analysis involves a step-by-step calculation of the motion of each machine in the system, the principle factors involved being the line reactances, machine synchronous and transient reactances, time constants of the machine field structures, governor and regulator actions, switching times, and machine inertias. Simplified methods of analysis in certain cases are available.*

THE RELATION OF SYSTEM CONNECTIONS AND APPARATUS TO STABILITY

An endeavor has been made to investigate the effects of various bus and apparatus arrangements in a typical transmission system which is required to withstand shocks ensuing from major switching operations and fault conditions.

In Fig. 16 is shown the simplified diagram of such a typical generating station delivering power over high-voltage transmission lines to a large interconnected system which is represented as an equivalent motor. The generating station is assumed to consist entirely of waterwheel generators. The power is to be transmitted over 154-kv. lines where two circuits are considered, and over 110-kv. lines where four circuits are considered. These ratios of voltages and number of circuits are chosen in order that the maximum steady-state powers

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†See Bibliography.

1. For references see Bibliography in complete paper.

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*See Bibliography I and Appendixes II and III.

under normal conditions may be equal. The curves in Part I show the results found in this particular study.

As a result of studies such as this, and also of practical experience, a discussion of various factors has been prepared. On account of space limitations, this abridgment includes only a few of the items presented in the complete paper.

Apparatus

(a) *Generators*

(*III*) *Damper Windings.* Damper windings have two effects: the first, a damping action, and the second, an increase in fault current and shock to the system. The latter effect is due to the reduction in generator negative-phase sequence reactance. If the shock to the system is relatively small, a slight increase in shock, because of the reduction in reactance, will not be serious. If the shock is so severe that synchronism will be lost without damper windings, their presence cannot make matters worse. There will be a critical shock which is just great enough to cause instability when no damper winding is used. Calculations made on typical systems have indicated that with a shock of this magnitude, the beneficial effect of damping exceeds the disadvantageous effect of increased shock. Furthermore, the presence of damper windings produces a markedly beneficial effect in extinguishing arcs more quickly, due to the reduction in the recovery voltage. Therefore, the use of low-resistance damper windings on water-wheel generators would, in general, appear desirable. Such windings should be especially desirable in cases where stability is determined after several swings. Field tests are required to verify these data.

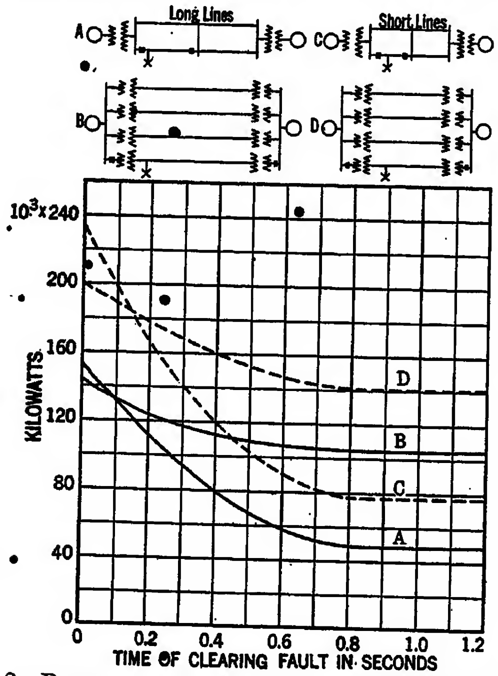

Fig. 2—Power which may be Carried Through a Two-Conductor-to-Ground Fault Outside the Generator Transformers *Versus* Time of Clearing the Fault.

——— Long lines
– – – – Short lines

(b) *Excitation Systems*

It has been definitely shown that regulators which act quickly are effective in improving stability. For example, as stated in paragraph (*I*) of the complete paper, under *Generators*, with proper regulators both steady-state and transient power limits may be materially increased. To accomplish this result it is necessary that the excitation systems be fast enough to respond sufficiently. The practical criterion of the speed of response necessary has been investigated and a tentative figure of 200 volts per second determined.[1, 16] Field tests should be made on an actual system to verify this decision.

The use of the appropriate type of regulator tends also to prevent hunting.

(c) *Neutral Impedance*

The effect of neutral reactors is to lower the shock when faults involving grounds are considered.

For conductor-to-ground faults the benefit is very great, and it is considerable for two-conductor-to-ground faults also. Quick switching tends to reduce the gain due to reactors, but even with 0.2 second switching time they still have a considerable value. The improvements which may be expected from the use of neutral reactors are shown in Figs. 6 and 7.

The amount of neutral reactance is necessarily a

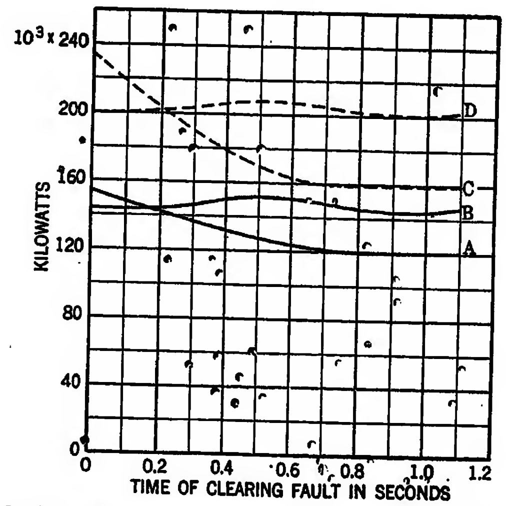

Fig. 3—Power which may be Carried Through a One-Conductor Ground Fault *Versus* Time of Clearing the Fault

For Diagrams see Fig. 2

——— Long lines
------- Short lines

compromise between gain in stability, reduction in circuit-breaker duty, reduction in current available for actuating relays, reduction in telephone interference, and an increase in phase voltage to ground during disturbances.

The latter consideration becomes important in connection with lightning arresters and overvoltage relays. Studies have shown that when ground relays are used, a reactor of about two and one-half to three times the reactance of the transformer is usually correct. In cases of sufficient importance, this figure should be checked by special calculation. The neutral reactance

so far discussed does not in any way approach the dimensons of a Petersen coil, and therefore does not involve resonance phenomena. The Petersen coil is merely a reactor which permits a reactive fault current equal to the line charging current-to-ground under fault conditions, and this reduces the fault current to a low value.[3, 4] In addition, it operates to cause the voltage across the arc to recover slowly in case the arc is extinguished. When the arc extinguishes, both the voltage across it and the dielectric strength of the arc space begins to increase. The arc will extinguish permanently if the recovery voltage across it is always less

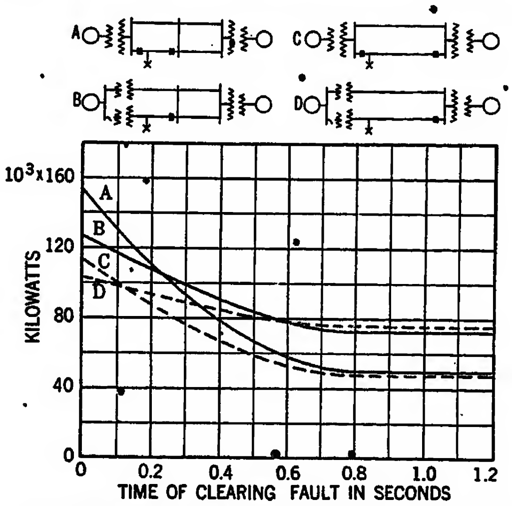

Fig. 4—Power which may be Carried Through a Two-Conductor-to-Ground Fault Outside the Generator Transformers *Versus* the Time of Clearing the Fault

——————— Long lines, mid-sectionalizing bus
- - - - - - - Long lines, no mid-sectionalizing bus
A and *C*......High-voltage Busses
B and *D*......Low-voltage Busses

than its dielectric strength.[24] Thus the magnitude of recovery voltage is a measure of arc stability. The magnitude of the recovery voltage in the first quarter cycle depends on the degree of "tuning" and is proportional to the ratio of fault current with the Petersen coil to the fault current without the Petersen coil. Even with only a moderate degree of tuning, this ratio is small and experience shows that even on widely distributed systems with large charging currents, the arc is unstable and goes out. Petersen coils are much used abroad, but have so far been used little in this country. Experience abroad would indicate that their use here should be reconsidered.

Neutral resistors may be of two types; current-limiting and braking. The former is of relatively high resistance and acts primarily to reduce the shock to the generator and the system having the fault. The latter is of low resistance and is used to load the generator, thus providing a braking action. With this type of resistor the shock to the generator is reduced, while the shock to the system is increased.

It has been shown[18] that the current-limiting type of resistor causes greater phase-to-ground voltages than a reactance would for the same gain in stability. Further, the reactor is usually cheaper. Therefore, in general, as a current-limiting device, reactors are preferable. Whether or not a braking type of resistor is preferable to a current-limiting reactor is a question which is not yet entirely clear. However, for general applications, the reactor appears preferable since the choice of braking resistor requires very careful study in each particular case, which is not the case with reactors. Furthermore with a braking resistor there is a greater danger of telephone interference than if either a current-limiting resistor or reactor is used.

(*d*) *Synchronous Condensers*

The authors believe that the use of synchronous condensers wholly or principally as an aid to stability is not, in general, desirable except, perhaps, in a few isolated cases. This belief is based on the observation of certain synchronous condensers under transient conditions and also on calculations of the type leading to curves shown in Figs. 24 and 25 of the complete paper. These curves show how slight is the gain obtained in the case for which the calculations were made. Thus it appears that normally condensers should be purchased only on the basis of their function in supplying wattless kv-a. In other words, it is thought that in most cases the gain is not sufficient to justify them solely on the basis of their stabilizing effect. In cases where it is desired to increase any stabilizing effect they may accomplish, this may be done advantageously by pro-

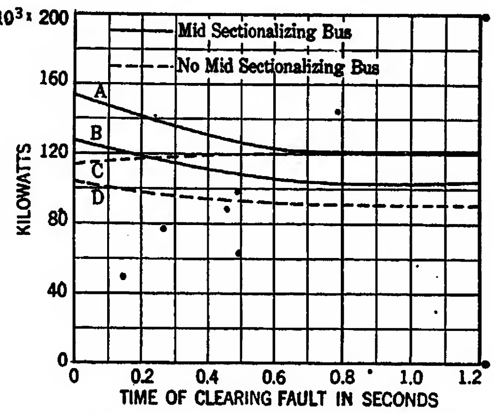

Fig. 5—Power which may be Carried Through a One-Conductor-to-Ground Fault outside the Generator Transformers *Versus* Time of Clearing Fault (See Fig. 4 For Diagram)

viding a balancing type of regulator and high ceiling exciters. When considering the use of condensers, it is important to bear in mind that they may not, and apparently usually do not, increase the transient limit as much as the steady-state limit.

(*e*) *Governors*

From a stability standpoint governors should operate quickly and should possess anti-hunting features tending to reduce swinging after disturbances. Governor operation in direct response to fault indication may prove desirable. Field tests as an aid to improvement of governor characteristics under transient conditions would be very desirable.

Automatic control of frequency is being tried on certain systems; to the extent that each system and each station holds very closely to the exact system frequency, the problem of tie-line loading should be simplified and a corresponding improvement in stability will result.

Switches and Relays

When the duration of short circuit is low, the impulse given to machine rotors is small, and hence stability is improved. From this standpoint, therefore, high speed in both relays and circuit breakers is very desirable.

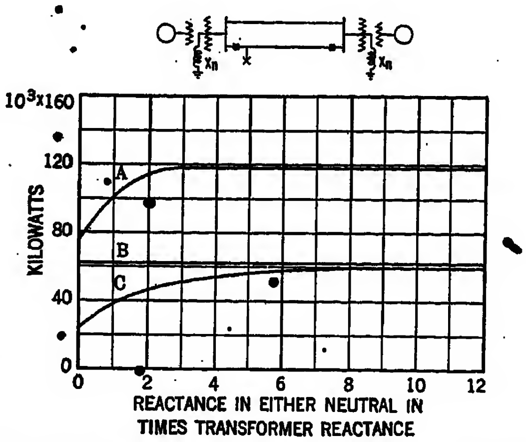

FIG. 6—POWER WHICH MAY BE CARRIED THROUGH FAULTS OUTSIDE THE GENERATOR TRANSFORMERS *Versus* REACTANCE IN EITHER NEUTRAL WHEN THE FAULT IS CLEARED IN 1.0 SEC.

Long lines with high-voltage busses and no mid-bus
A One conductor-to-ground fault
B Conductor-to-conductor fault
C Two conductor-to-ground fault

TABLE I

Time of clearing fault in seconds	Power which may be carried through a two-conductor-to-ground fault
0.0	100 per cent
0.1	83 per cent
0.2	68 per cent
0.3	56 per cent
0.5	42 per cent
0.75	33 per cent

Table I shows the average reduction in power limit over transmission systems involving waterwheel generating capacity due to delayed switching,* with power limit at zero switching time as reference, for two-conductor-to-ground faults.

SYSTEM CONNECTIONS

(a) *High-Voltage Bus**

The use of a high-tension bus either at the generator or system end of the line or as a mid-bus results in a maximum shock during the occurrence of a fault, but a minimum reduction in synchronizing power after the faulted line has been cleared. If the shock is already small as in the case of a single-conductor-to-ground fault when neutral reactances are employed, or if the duration of the fault is short as when high-speed switches are used, this is a desirable arrangement from a stability standpoint. If these conditions do not exist, this type of arrangement may prove unsatisfactory.

*Figs. 4 and 5 show the comparison between high- and low-voltage busses

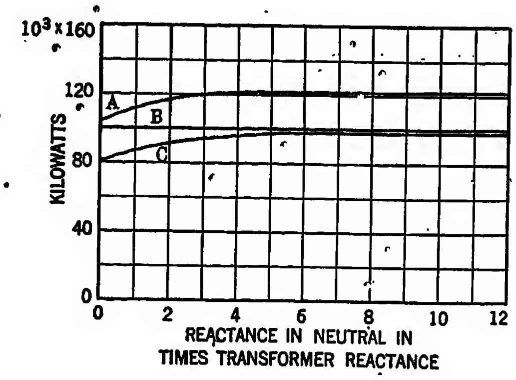

FIG. 7—POWER WHICH MAY BE CARRIED THROUGH FAULTS OUTSIDE THE GENERATOR TRANSFORMERS *Versus* REACTANCE IN THE NEUTRAL WHEN THE FAULT IS CLEARED IN 0.2 SEC.

Long lines with a high-tension bus and no mid bus. For diagrams see Fig. 6
A 1 conductor to ground fault
B Conductor to conductor fault
C 2 conductor to ground fault

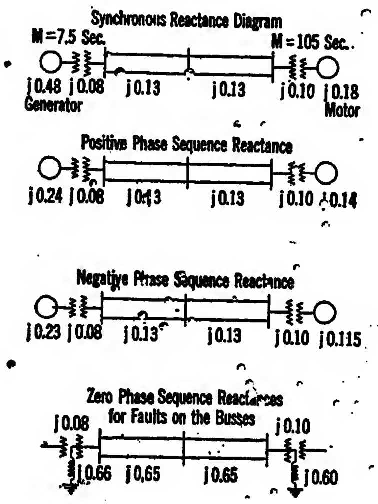

FIG. 16—DIAGRAM SHOWING DISTRIBUTION OF REACTANCES IN A SAMPLE SYSTEM WHICH HAS BEEN USED TO DEMONSTRATE THE EFFECT OF BUS ARRANGEMENTS. WHEN LOW-TENSION BUS ARRANGEMENTS ARE CONSIDERED, THE REACTANCES ARE SIMILAR

Reactance base 120,000 kv-a., 154 kv.
Generator capacity 120,000 kv-a.

(b) *Low-Voltage Bus**

A low-voltage bus has the advantage over a high-voltage bus that the reactance to the fault is increased. On the other hand, when the fault clears, the synchronizing power is less than with a high-voltage bus. If there are several lines,—say four or more,—the low-voltage bus is very advantageous. A further advantage

is that high-speed switching is not required, provided that faults do not involve more than one conductor.

For long distance transmission, this arrangement will usually be uneconomical, but for transmission over relatively short distances, it offers great promise. The curves in Fig. 2 show the indicated results with this arrangement.

(c) *Split Bus*

Another solution is to use a low-voltage bus at the system end of the line and to split the lines at the generator end, putting part of the generating capacity on each bus.[5, 6, 7] When this is done it is usually possible for the generators on any one line to ride through the disturbance occasioned by a fault on another. However, for long distance transmission lines even with this arrangement a higher speed of switching than has heretofore been commonly available in the higher voltage switches will be required to insure stability.

It seems possible that high transformer reactance at the system end of the line may be beneficial with this arrangement since it tends to reduce the shock to the generators on the unaffected lines. This point is being investigated.

Conclusion

One outstanding conclusion which may be derived from the foregoing discussion is that the development of high-speed high-voltage circuit breakers and relays will mark the greatest single advance in the solution of present stability problems.

Acknowledgment

The authors gratefully wish to acknowledge the contributions to this article by Mr. R. H. Park. They also wish to thank Miss Edith Clarke and Messrs. E. M. Hunter and Myron Zucker for their assistance in the preparation of the paper.

Applications to Marine Work

ANNUAL REPORT OF COMMITTEE ON APPLICATIONS TO MARINE WORK*

To the Board of Directors:

The activities of the Committee on Applications to Marine Work this year were devoted chiefly to the consideration of future revisions in the Marine Standards (A. I. E. E. Standard No. 45) and in further efforts to induce the U. S. Steamboat Inspection Service to arrange for proper recognition and classification of the electrical engineer on shipboard. Owing to the few active matters for consideration by the committee, and the unusual activity in new marine construction placing a large demand upon the time of most of the committee, the meetings of the committee were curtailed.

For certain reasons not pertinent to this report, the committee's progress with the U. S. Steamboat Inspection Service has been extremely slow, even though the committee has done considerable constructive work to assist in bringing about a solution. Apparently, certain obstacles have been encountered which will have to be economically dispensed with if our efforts are to succeed; however, the committee is hopeful of a final solution which will obtain for the electrical engineer the recognition and classification which he deserves. It is recommended that the committee pursue this activity with unceasing efforts and possibly through other channels.

*COMMITTEE ON APPLICATIONS TO MARINE WORK:

W. E. Thau, Chairman,

Edgar C. Alger,	Wm. Hetherington, Jr.	Wm. H. Reed,
R. A. Beekman,	H. L. Hibbard,	Edgar P. Slack,
H. C. Coleman,	A. Kennedy, Jr.,	H. M. Southgate,
E. M. Glasgow,	J. B. Lunsford,	Oscar A. Wilde,
H. F. Harvey, Jr.,	E. B. Merriam,	J. L. Wilson,
C. J. Henschel,	I. H. Osborne,	R. L. Witham.
	G. A. Pierce,	

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The past year has seen the following major marine activities in which electricity has contributed its full share:

1. The placing in service of five turbine electric drive U. S. coast guard cutters. These ships use the dual-drive system for the auxiliaries.
2. The placing in service of the 18,000-ship hp. twin screw turbine electric drive passenger vessel, *S. S. Virginia*, a sister ship to the *S. S. California*.
3. The construction of a third 18,000-ship hp. turbine electric drive passenger vessel, *S. S. Pennsylvania*, a sister ship to the *Virginia* and the *S. S. California*.
4. The construction of two 14,600-ship hp. twin-screw turbine electric drive vessels for the Ward Line.
5. The construction of a 12,600-ship hp. twin-screw turbine electric drive vessel for the Grace Line.
6. The placing in service of three 4000-ship hp. single-screw Diesel electric drive cargo ships: *M. S. Courageous, M. S. Triumph,* and *M. S. Defiance* by the *U. S.* Shipping Board.
7. Several smaller craft utilizing Diesel electric drive.

The results of the Jones-White Act are already being felt by the marine industry. A few large ships taking advantage of the provisions of this Act are in the course of construction and contracts for several large vessels are pending, most of which will probably employ turbine electric drive.

The use of electric auxiliary machinery is established, and in most cases the auxiliaries throughout the ship are driven electrically.

Abridgment of

General Power Applications

ANNUAL REPORT OF COMMITTEE ON GENERAL POWER APPLICATIONS*

To the Board of Directors:

Your Committee on General Power Applications has attempted to keep in close touch with the development of power applications during the year through the selection by the various members of the committee of specific industries in which they were deeply interested and on which they agreed to furnish a condensed report early in 1929.

No attempt has been made to cover the entire industrial field so that there are undoubtedly many new applications which have not been brought to the attention of your committee. An effort was made, however, to cover the outstanding developments in basic industries which should be a true measure of the advance during the past year.

Marine Equipment

During the year 1928 there were placed in commission or under construction, a total of 38 electrically-propelled vessels of various sizes and types ranging from the small river towboat to the most modern of passenger liners. The aggregate shaft horsepower of the electrical equipment in these vessels was over 132,400, of which 88 per cent was supplied by turbines and 12 per cent by Diesel engines. However, of the 38 vessels electrified, 24 were of the Diesel-electric drive.

Outstanding developments in the application of electricity to marine work during 1928 were the launching of the largest electrically-propelled passenger liner, the *Virginia*, the breaking of all existing speed records for capital naval ships by the airplane carriers, *Saratoga* and *Lexington*, and the installation on three freighters owned by the U. S. Shipping Board, of the biggest d-c. motors ever put on a ship.

Electric Railways

Although electric railways come under the jurisdiction of the Transportation Committee, there are several unusual applications of power in this field which it will be well to mention briefly.

To speed up the classification of freight and to eliminate so far as possible the hazardous occupation of car riding, several railroads have adopted electric retarders in their hump yards. The apparatus required consists of a motor and brake coupled to a gear mechanism adjacent to the retarder with remote-control to enable operation from conveniently located towers in the freight yard.

The year also was marked by the number of oil electric locomotives and gas electric motor cars put in service by the railroads. Ranging in size from 60 to 150 tons, and in power from 100 to 900 hp., oil electric locomotives were successfully used by both railroads and industrial plants.

The popularity of the gas electric motor car is indicated by the total of 117 cars placed in service during the past year. These cars are rapidly replacing steam trains on the short branch line roads.

Distillate fuel has been successfully used in place of gasoline by several companies operating gas-electric trains. This fuel has also been adopted by a large city transit company for use in its gas electric busses.

In the street railway industry there has been a decided tendency toward lighter and faster motors, lighter car bodies, and improved methods of drive.

Steel Mill Industry

The total horsepower of main-drive motors installed by steel companies during 1928 reached 212,300, with an average motor size of 1250-hp. Of this total, approximately 80 per cent are d-c. machines.

During the year there were several outstanding installations where steam engine drives were replaced by d-c. reversing motors. The largest d-c. motors in the world are now found driving the big reversing mills of the steel industry.

Strip mills are a distinctly new development and are gradually replacing the old sheet mills for doing the same work. The new continuous hot strip mill of the American Rolling Mill Company at Middletown, Ohio, is the highest powered of any strip mill yet built. The main rolls are driven by 21,800 hp. in motors; four 3000-hp., and three 2000-hp. d-c. motors on the finishing end, and 3800-hp. in induction motors on the roughing end. This mill purchases 66,000-volt power and has three 4000-kw. motor-generator sets to supply direct current for the main roll motors.

Material Handling

During the past year, industry as a whole was much benefited by the improvement and increase in the number of applications for handling materials electrically. In many cases the removal of the human element has resulted in astounding increases in plant efficiency, while in certain industries the development of proper equipment for handling odd shapes and sizes

*COMMITTEE ON GENERAL POWER APPLICATIONS:

J. F. Gaskill, Chairman.

D. H. Braymer,	A. C. Lanier,	W. W. Price,
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Harry L. Grant,	A. M. MacCutcheon,	A. H. Stebbins,
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generally conceded forever assigned to unskilled labor has effected considerable saving.

In general the year was characterized by the application of mechanical handling to a wider variety of uses.

Equipment for handling freight cars was further developed during the year. One of the newest type car dumpers, capable of dumping a car a minute, is being constructed for the New York Central Railroad at Toledo, Ohio. The total electrical equipment aggregates 3000 hp. and consists of both a-c. and d-c. motors with special control by means of variable voltage.

Two other installations now under construction for loading ships, one at New Orleans and the other at Havana, Cuba, are of an unusual type. This equipment will load refrigerating cars on a ship specially designed with tracks to handle about 95 cars. These cranes will lift 165 tons at the rate of 50 ft. per minute and use two 250-hp. totally enclosed mill type d-c. motors for drive. These cranes are the first ever designed for loading and unloading ships with standard freight cars.

Prior to 1928 the largest electrical shovel was the 8-cu. yd. or 300-ton shovel. A number of 12-cu. yd. capacity shovels was placed in service during the past year. Due to the extreme fluctuation of current demand, it was necessary to design special equipment for the drive and control of these shovels. Three motor-generator sets, with the generators all differentially wound, are capable of generating 750 kw. The four motors for the various drives aggregate 650 hp. One of these shovels recently established a new world's record for material handled when it moved 15,497 cu. yd. of overburden in 24 hr.

Numerous other improvements in material handling have been made during the year, especially in regard to the method of connecting the drive to the conveyor, as well as the use of anti-friction bearings, gear replacement of pulleys, and other similar refinements.

Paper Industry

The paper industry was long since converted to motor drive of the main rolls, but this year has seen the principle pushed still further. Cylinder machines have a larger number of small rolls, baby presses, and cylinder molds, which heretofore have been driven by the felt carrying the paper pulp. The long, broad belt of high grade felt is decidedly expensive, and the practise of using it as a drive necessitated frequent replacements. A new mill at Port Townsend, Washington, eliminated this illogical expense; small motors, held in extraordinarily exact speed agreement, drive each element.

Carbon pile regulators, which have been successful in the control of single-motor paper mills elsewhere, have been further developed to aid in the exact speed regulation of the Port Townsend machines.

A variable-speed turbine with reduction gear was an important development in isolated power plant equipment for paper mills. The low-speed end of the gear is connected through sheave pulleys to the paper mill and exhaust steam from the turbine is used in the can dryers. Speed can be held within very narrow limits between 65 rev. per min. and 390 rev. per min. on the driven shaft. This unit is rated at 475 hp. at 4200 rev. per min. and operates at 110 lb. gage steam pressure with back pressures varying from 20 to 40 lb. gage.

Cement Industry

Productive capacity far in excess of normal consumption has caused the cement industry to turn to electricity for economical operation. New plants are universally electrically driven while mechanical drives are rapidly being replaced in the older mills.

Isolated generating plants utilizing the heat from cement kiln gases are still popular although during the year several contracts were signed with public utilities calling for an interchange of power. While this exchange provides an outlet for the excess power of these plants, it also places a premium that formerly did not exist on economies in power generation and mill operation.

Notable developments have been several specialized types of synchronous motors designed to provide the high torques necessary for heavy crushing and grinding machinery.

Another application of the synchronous motor is on hammer mills. A novel feature of this installation is the overload relay. When the overload is great enough to pull the motor out of step, the relay operates, cutting off the material being fed to the hammer while permitting the motor to regain speed, running as a straight induction motor.

Push-button control has become almost universal, even for motors of the smaller sizes. One large mill, completed this year, points with pride to the elimination of starting equipment other than push-button controlled, full automatic circuit breakers of high interrupting capacity. Low starting kv-a. of the motors has made such installations possible; in some cases, the motor starts directly across the line.

An important application of specialized control is the automatic blending of dry cement materials as developed in connection with the Fuller-Kinyon System. The Fuller-Kinyon pumps handle the pulverized rock mixture like water, and a very ingenious control system for the pumps and valves has been designed. Electrical interlocks and time clock regulation permit almost unlimited combinations for blending the contents of bins or silos to produce a constant quality feed for the kilns.

Mining

The coal mining industry endeavored during the past year to solve many of its troubles by the wider application of electricity and the adaptation of more adequate and more efficient machinery.

An outstanding feature of the year was the new mine locomotive built for the Pemberton Coal and Coke Company, Bluefield, W. Va. This locomotive, although weighing only 30 tons, develops 532 hp. and will haul a

full load of 168 tons up a 1.5 per cent grade at 10½ mi. an hour. Electropneumatic control and air-brakes are features which are most unusual on this type of locomotive.

Ore Reduction. The first commercial size plant in this country to utilize the Tainton process, *i. e.*, strong acid and high current density for the electrolytic reduction of zinc, was installed by the Sullivan Mining Company at Kellogg, Idaho. Current is supplied by two three-unit 4000-kw. motor-generator sets.

The Anaconda Copper Mining Company during 1928 put in operation the largest motor-generator sets ever used in an electrolytic zinc plant. There are four three-unit sets, each rated at 5500 kw.

Oil Industry

As the oil industry passes the stage of adventuring with its picturesque engine and rig, and becomes more and more a leading industry with an economic problem of conservation, it is marked by the application of electricity to give the best results at the lowest cost. Well-drilling has become an affair requiring large capital, as several wells have already cost over a quarter of a million dollars and have reached depths of over 8000 ft. One well in West Texas has been drilled 8255 ft. or 1.56 mi. deep and is the deepest hole ever dug by man. Two 25/65-hp. oil well motors, driving a cable tool rig, supply the power for the drilling which is still continuing.

Until very recently it was thought impossible to apply centrifugal pumps to oil pipe lines. A development of suitable high-speed centrifugal pumps which would not emulsify the oil enabled the economic use of electrical drive. A new pipe line, 400 mi. long, went into service during the past year, using this equipment. Forty-four 400-hp. squirrel-cage, 1800-rev. per min. motors drive the pumps in the 13 stations along its length.

Electric Welding

Only a few of the more important developments in electric welding can be mentioned in this short résumé. One of the most important advances has been the increased size of the electrode used, which, in general, reduces the time for welding in about the inverse proportion to the size of the electrode.

Another development of considerable importance is the introduction of the new atomic hydrogen method of electric welding, which makes possible the welding of thin metals and alloys that could not be welded before because of the oxidation of the materials by the heat of the arc. This new method introduces hydrogen gas into the arc flame, the gas being broken down into atomic hydrogen by the heat of the arc. This atomic hydrogen effectively prevents oxidation of the materials so that a satisfactory joint can be obtained. This enables countless small objects, which otherwise would require more expensive methods of union, to be welded.

The importance of electric welding in the industrial field can be emphasized by the faith of the Ford organization in this type of welding. It is stated that the Ford Company has recently expended over $100,000,000 for equipment and methods to produce their new model "A" car, which depend primarily on electric welding. Here electric welding is reduced to an almost automatic process requiring very little personal supervision.

A new process was developed for producing electrically-welded railroad ties from scrap rails, which is done entirely automatically and produces a very satisfactory tie at a low cost from scrap material.

Industrial Heating

During 1928 the use of electricity for industrial heating has increased rapidly due to the development work of the manufacturers and the recognition of the central stations to the desirability and importance of the load.

Electric Stereotyping. The first electric stereotype pot was built and installed in 1925, but it has been during the past year that most of the large installations were made. More than 100 are now in operation, varying in size from 40 kw. for small pots to 360 kw. for large 9-ton pots. The pots make use of an immersion element placed in the lead with automatic temperature control. The total load in many metropolitan plants runs from 800 to 1500 kw., connected load, for this service. Indications point to the complete electrification of stereotype pots in the next few years.

Silk Moistening. An important application has occurred in the full-fashioned hosiery manufacturing field for the moistening of silk before passing through the needles of the knitting machine. Units consisting of an insulated box, containing water with felts for the silk to pass through and having electric heating units of 173 watts each, are placed so that from 3 to 7 threads are moistened on the way to the needles.

The water is kept at about 160 deg. fahr. and the evaporation of water moistens the felt so that the silk picks up enough moisture to eliminate back winding.

Loads of 990 kw., connected in one plant, have been noted, and in the Philadelphia district, approximately 2000 kw. is in use in this class of business.

Electric Brazing Furnaces. The application of electric furnaces to copper brazing steel parts together has made possible the assembly in one operation of complicated structures from simple parts by a strong alloy weld. This is accomplished by placing copper wire or chips next to joints to be brazed, and then heating the assembly in a furnace containing a hydrogen atmosphere to a temperature above the melting point of copper.

In the process of brazing, the hydrogen performs the function of a flux as well as excluding air from the heating chamber.

Both intermittent and continuous types of furnaces are in use for this work and have extensive application in the assembly of refrigerator evaporation shells.

The use of protective gases in other type electric

furnaces is recognized as metallurgically beneficial in the heat treatment of various steels and in cases where bright annealing is essential.

High-Frequency Furnaces. Recently the application of the high-frequency induction type furnace to melting and heat treating steel has been given greater consideration. Furnaces are in use for making cast steel in ingot form for production work and for heat treating high-speed steel in liquid baths.

Gray Iron Melting. The application of the indirect arc type electric furnace to the production of synthetic cast iron is a comparatively recent development. Gray iron borings from the manufacturer's machine shop, which have a very small market value, are utilized in the production of iron of good physical properties, and the over-all melting cost per ton is less than that for cupola operation. This has opened a new field for development in the iron industry.

CONTROL

During 1928 improvements in design and applications of control have been in keeping with the general trend of the past several years. Although a great many individual instances could be cited, a few general examples will be sufficient to indicate the general trend of the various types of control equipment.

Most of the motor control is now of the definite time accelerating type. A time—current control has developed for d-c. equipment which provides maximum time saving in motor acceleration within predetermined current limits under conditions of light or normal loads and forced acceleration at a predetermined rate where the load is too heavy for the motor to start with the normal accelerating current setting.

The conventional form of master switches, using segments and fingers, has been replaced in the last few years by the cam-operated switches. The past year produced further development of the cam operation, special attention being paid to simplicity of design. An outstanding example of this is a small, compact device which was designed to fulfill three purposes,—controller, disconnect switch, and overload relay. A complete line of master switches was also produced which required only a few different fundamental cams to obtain a great variety of combination of contact sequence. Still another indication of the trend towards simplified design is in the compact limit switch developed for use on motor-driven valve equipment. By means of intermittent gears it is possible to get an adjustment of from 1 to 1365 turns on the valve stem.

Push-button control incorporating simplicity and sturdiness of design without sacrificing dependability of service is rapidly replacing the cumbersome and complicated control systems of a few years back.

MISCELLANEOUS APPLICATIONS

Rubber Industry. The large expansion of this industry in the past few years has caused engineers to devote their attention to new plants and extensions to present mills rather than the development of new applications. The slow-speed synchronous motor has been the predominant type in new installations. Full-voltage starting, together with dynamic braking, has been almost universally adopted. All new installations have the thermal, and particularly the thermostatic, type of overload protection.

Power Applications in Telephone Industry. Power applications in the telephone industry are naturally limited. The drives that are used generally make only small power demands and are commonly rather special in their nature. Special motors are required for television and sound pictures, with very ingenious speed regulation; but they are of too narrow scope for discussion in this report. The development of large capacity filters to eliminate noise-producing ripples in the generating current has permitted the application of standard generators for telephone battery charging.

Small Motors. Improvement in design of small motors was apparent during the year. Single-phase motors received a great deal of attention, and the improvements made will be of considerable advantage to various industries.

Single-phase repulsion induction motors, ranging in size from ¾ to 2 hp. at 1800 rev. per min., were produced with a high-starting torque and constant speed. Better magnetic utilization of the steel was accomplished in these motors by using square stator punchings with graded slots.

Single-phase condenser motors having practically the same efficiency as a two-phase motor and operating at or near 100 per cent power factor were designed. The motor develops even more torque than the two-phase motor, whereas the current required is considerably less.

Recent tests in the textile industry have indicated the desirability of applying the a-c., brush-shifting, shunt-characteristic polyphase motor for obtaining variable speed in the spinning of cotton as well as worsted yarns.

Electric Elevators. The development of high-speed, full, and semi-automatic elevators was furthered during the year. Deficiencies affecting the riding qualities of elevators in the automatic control of the rates of acceleration and retardation were removed by the application of a small auxiliary d-c. machine to act upon the generator field of the motor-generator set of the generator-voltage type of elevator drive. By this means, the acceleration and retardation are caused to begin at very moderate rates, increase to higher rates and again diminish as the speed change nears completion.

An automatic leveling system was developed, embodying a radical departure from previous practise. This system utilizes radio-frequency devices wherein, the position of the car with respect to the floor controls the leveling speed of the elevator accordingly. The particular advantage of this control is the elimination of all mechanical engagement with its noise and ultimate

deterioration, a minimum clearance of ⅜ in. existing between the parts on the car and the corresponding part in the hatchway.

Printing. The main advance during the past year in the printing industry has been the increase in the speed of the presses. Where a few years ago, 24,000 to 25,000 papers an hour were considered good production, presses today operate at the rate of 60,000 to 75,000 papers an hour. This has meant the application of higher speed motors in some cases, while in others, it was simply a matter of increasing the gear ratio. The horsepower of the motors has increased in proportion, while new improved and simplified methods of control have accompanied the change.

Spray and Fog Tests on 220-Kv. Insulators

BY R. J. C. WOOD[1]

Associate, A. I. E. E.

Synopsis.—To determine insulation for an outdoor 220-kv. station on the coast subject to ocean spray, an insulator test rack was installed at Redondo, California.

Ten types of insulator, including widely different designs, were tested continuously for two years and a half at 150 kv. to ground. Comparative results were obtained by adding or subtracting units in suspension strings until an equality against arc-over was approximated. Ninety arc-overs occurred.

The surface leakage resistance was found to be a fair index of the resistance to arc-over under salt spray conditions. The shape of the insulator made no difference as long as the total surface resistance of the string remained the same.

The surface resistance is that calculated upon the assumption of a uniform conducting coating upon all the exposed surface of the insulator and is the line integral of distance divided by circumference along the shortest surface path from cap to pin.

Accidental differences of conditions are such that one insulator string would not consistently arc-over in preference to another unless its surface resistance were less than 80 per cent of the other.

Suspension strings having a total surface resistance of 11.0, using inch units, were found satisfactory for a steady 150 kv. to ground under the conditions at Redondo.

A spray method of cleaning insulators while energized was devised.

Introduction

In the latter part of 1926 it was seen that it would soon become necessary to decide upon the kind of insulation to be used in the Southern California Edison Company's 220-kv. outdoor station that was to be built

Fig. 1—Test Rack, Energizing Transformer, and Two Small Transformers Used as Reactors. Looking North

at Long Beach, on the coast south of Los Angeles.

A test rack was therefore set up at Redondo on the coast, the location being chosen as one of the most subject to ocean spray and fog upon the system, and where considerable insulator trouble on both 66-kv. and 16-kv. lines had been experienced.

Climatic Conditions

The storm winds are westerly and drive the spray from the ocean surf directly into the test rack, the accumulation of salt upon the insulators having been

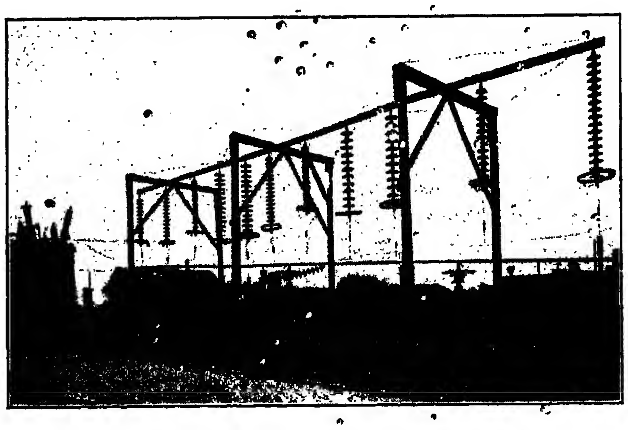

Fig. 2—Test Rack. Looking Southwest

such at times that during the heat of the day small crystals of salt have been observed scattered all over the surface of the porcelain. At night the deposition of moisture upon the insulators is frequently sufficient so that they drip and the sandy soil underneath is all pock marked

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from the dropping water. In addition to the salt deposit there is a certain amount of dust and sufficient soot to blacken any rag used for cleaning.

The time of year during which arc-overs are most prevalent is from March or April until the first rains of the season, which may come in September or October.

Description of Apparatus

The rack illustrated in Figs. 1, and 2, was situated

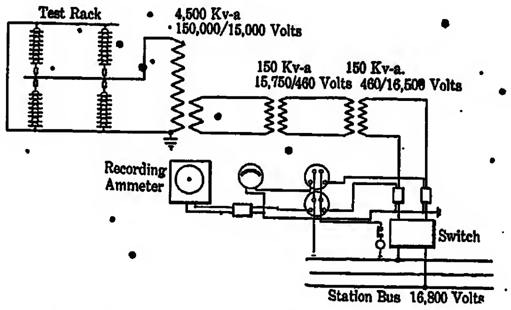

Fig. 3—Diagram of Connections between Station Bus and Test Rack

about 500 ft. from the ocean front. The pipe bus was energized to 150 kv. to ground.

Electrical connections were as in Fig. 3, the two 150-kv-a. banks of transformers in series with the 4500-kv-a. transformer being used as reactors to limit the short-circuit current to 10 amperes over an insulator and 100 amperes on the station bus.

To indicate which of the insulator strings had arced-over, a one-ampere enclosed fuse was connected between each insulator string and the bus. These fuses were further protected against weather and corona by short lengths of one-inch pipe and may be seen in Figs. 1 and 2.

The types of insulator tested are shown in Fig. 4; some of their physical constants in Table I. The quantity called "Surface Resistance" is not any measured resistance, but is the calculated surface leakage resistance from cap to pin of a single insulator unit, assuming the exposed porcelain surface to be uniformly coated with a conducting layer. Should the conducting layer have a resistance of one meghom per square inch, then the figures of Table I give the surface resistance from cap to pin in megohms.

The rack was kept energized both day and night whenever possible; an arc-over would cause the relays to open the main 16-kv. switch; the operator would at once close the switch again; if upon the third trial the arc-over still persisted the switch would be left open until the next day. Arc-overs practically always occurred during the night when fog or dew was heaviest.

Program of Tests

During the period from January 1, 1927, to June 1, 1928, a number of rather long suspension strings was

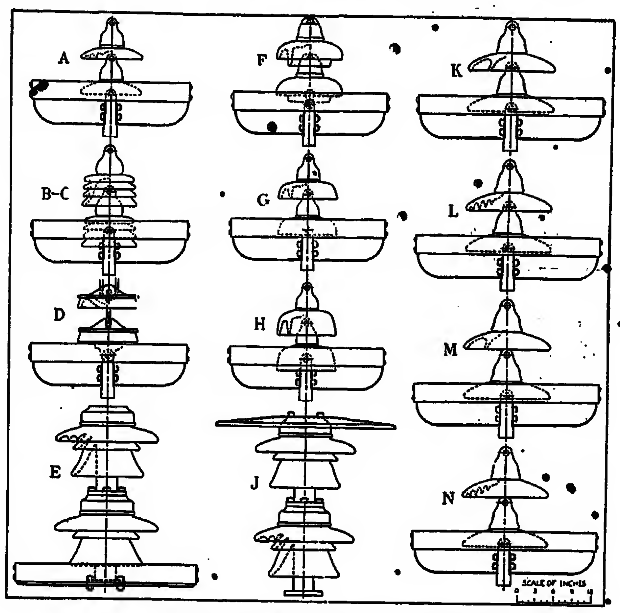

Fig. 4—Types of Insulator Under Test

under test, no changes being made except to disconnect two short strings of 13 Type *A* and 13 Type *D* which arced-over.

The strings under test during this period are detailed in Table II. They were all washed by hand on February 9, 1927. 6-*E* and 6-*J* were washed immediately after each arc-over, and 5-*J* was washed frequently as described later.

TABLE I
PHYSICAL CONSTANTS OF INSULATORS: INCH UNITS

Type	Diameter	Leakage distance	Surface resistance	Resistance per inch leakage	Axial length per unit	Resistance per axial inch
A	10	10.75	0.651	0.0605	5.75	0.1132
B	9	20.0	1.062	0.0531	6.5	0.1634
C	9	18.25	0.955	0.0523	6.5	0.1468
D	10	11.0	..	..	5.37	..
E	17	33.0	1.163	0.0352	14.5	0.0802
F	11	16.5	0.811	0.0492	5.75	0.1411
G	10	13.12	0.715	0.0545	5.75	0.1244
H	10	15.5	0.837	0.0540	5.75	0.1455
J	17	33.0	1.163	0.0352	14.5	0.0802
K	14	16.5	0.848	0.0514	6.6	0.1285
L	14	19.0	0.908	0.0478	6.6	0.1375
M	14	16.5	0.848	0.0514	8.0	0.1060
N	14	19.0	0.908	0.0478	8.0	0.1135

Note: Resistance is not easily calculated for Type D. From test results it seems to have approximately the same resistance as Type A.

Beginning June 1, 1928, the program was changed. Strings 8-*E*, 7-*E*, 6-*E*, were removed (the number and letter designating the number of units of a certain type).

The other types in service had the effective number of units in a string reduced by short-circuiting any required number of units, at the upper end of the string, with wire.

TABLE II
INSULATOR STRINGS UNDER TEST 1-1-27 TO 6-1-28

Number in string	Type and position	Leakage distance	Surface resistance	Period under test
13	A suspension	140	8.47	1-1-27 to 3-12-27
17	A "	183	11.06	1-1-27 to 6-1-28
15	AA dead end	161	9.77	1-14-27 to 6-1-28
15	AA " "	161	9.77	1-14-27 to 6-1-28
12	B suspension	240	12.75	1-1-27 to 6-1-28
13	D "	143	..	9-23-27 to 2-1-28
6	E "	231	6.98	1-1-27 to 6-1-28
7	E "	231	8.14	" " "
8	E "	264	9.30	" " "
5	J post	165	5.81	" " "
6	J "	198	6.98	" " "
7	J "	231	8.14	" " "
15	K suspension	248	12.72	" " "
12L + 3	K "	278	18.43	2-10-27 " "
12	M "	198	10.17	1-1-27 " "
12	N "	228	10.89	2-10-27 " "

The general practise was then followed of adding a unit, by moving the short-circuiting wire, on any one string after it had arced-over on two separate days. This wire device enabled units to be added or subtracted without handling the units and changing their surface condition.

It was expected in this way to arrive gradually at an equality in the different strings.

Types *H* and *G* were not put on test until October 15, 1928; Types *C* and *F* were added January 10, 1929.

In order to get comparative results, types *C*, *F*, *G*, *H*, *N*, *M*, were all washed by hand on January 15, 1929, so as to have them in the same condition as the recently added types. None of the other suspension strings had been washed, except by natural rains, since February 9, 1927, and they were now left in that state but reduced in number of units per string and the process of building up to an equality started in again.

On June 15, 1929 the program was again changed and all types, except the posts *J*, had units added until there was one more unit in each string than the maximum number that had arced-over at any time.

Arc-Overs

The first period of the test showed that neither the five- nor six-unit post, type *J*, would be satisfactory without periodic cleaning; it was found feasible, however, to spray the five-unit post with water, while energized, without danger of its arcing-over, provided the spraying were done frequently. Cleaning once a week apparently kept this post in good condition. The special spray-nozzle used washed practically the entire porcelain surface.

13-*A*, 13-*D* proved inadequate, each arcing over twice. There were six arc-overs on 6-*E* in suspension and three on 6-*J* as a post, in each case the insulator being hand washed immediately after arcing-over. This difference in behavior between post and suspension may have been due to the slight difference in the shielding, or to the cap in one case and the pin of the insulator in the other being at bus potential or, what seems most probable, that at the greater elevation above ground of the suspension string there was a greater wind velocity and more spray and dirt were deposited upon the porcelain; heat radiation would also be greater in the more exposed position and deposition of dew greater,—all of which would render the suspension string more liable to arc-over than the post. The post 5-*J* arced-over four times but not after regular washings were inaugurated. No relative values for the remaining suspension strings were obtained as none arced-over. Altogether there were 17 arc-overs in this period.

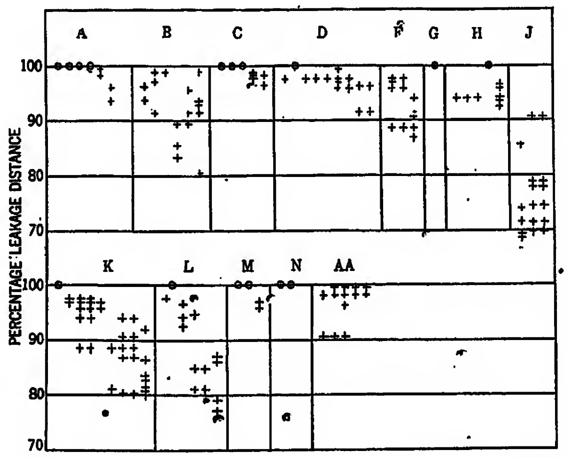

FIG. 5—COMPARISON OF TYPES UPON A LEAKAGE DISTANCE BASIS

The insulator string having the shortest leakage distance is not always the one to arc-over. Each cross shows the percentage leakage length of a string that was shorter than the one arcing-over. A circle shows the shortest arcing-over.

From June 1, 1928 to September 30, 1928 there were 30 arc-overs. The first rain of the season occurred October 11, 1928, and no further arc-overs took place until March 4, 1929. From March 4, 1929 to July 19, 1929 there were 43 arc-overs, giving a total of 73 arc-overs from which to analyze the relative performance of the different types of insulator.

Analysis of Arc-Overs

In Fig. 5 each flashover has been plotted with a view to seeing whether the leakage distance might not be the controlling factor in arc-over; if so, the string arcing over should have the least leakage distance of all under test. When this was the case it was plotted as a circle at 100 per cent. When, however, there were one or more strings having lower leakage distances than the one arcing-over, then they were plotted as crosses showing their leakage distances as a per cent of that of the string that arced. Thus in Fig. 5 any type which has many

low-percentage plots is apparently not so good as one in which the plots are of a higher percentage, remembering that the comparison is not unit per unit, but is based upon strings of equal leakage distance.

It is seen at once that this basis of comparison is not entirely satisfactory. Due to the unavoidable variations in amount of deposit, dew, wind, no two strings of insulators subjected to field conditions would ever behave exactly in accordance with any of their physical dimensions, except by accident. It would, however, be expected that they would average in some relation to some measuring stick, each exhibiting departures on either side of a mean. When these departures from the mean were the same for each, then they would be considered as equal, according to the particular basis of measurement chosen. Extending this argument to a number of different types of insulator, a true basis of comparison will have been found if in such a plot as Fig. 5 all the types exhibit equal divergencies. It is seen at once that Fig. 5 fails chiefly with respect to Type J, which by reason of its position should show up better than all others. Fig. 5 shows it as the worst. The intercomparison of the other types is fair in view of the fact that C, F, G, H, N, M, were all washed January 15, 1929, and would be expected to show up better than the others last washed February 9, 1927. It will be found significant that the ratio of surface resistance to inch of leakage distance does not vary over a wide range until Type J is considered.

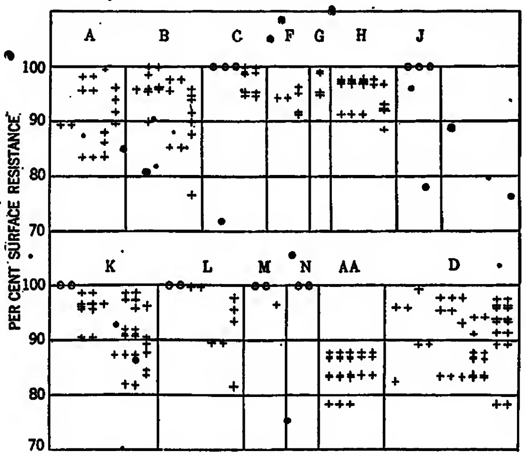

Fig. 6—Comparison of Types upon a Surface Resistance Basis

Each cross shows the percentage resistance of a string that was less than that of the one arcing-over. A circle shows the lowest resistance arcing-over

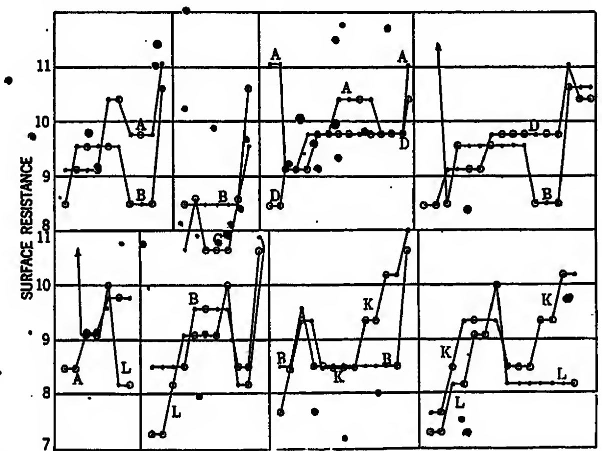

Fig. 7—Comparison of Types by Pairs upon a Surface Resistance Basis

The string arcing-over is marked with a circle vertically over or under the one not arcing. Insulators not washed since Feb. 9, '27

In Fig. 6 a plot similar to that of Fig. 5 is shown, the total surface resistance of the string, instead of the leakage distance, being made the basis of comparison. Type D is given an arbitrary resistance per unit equal to that of Type A for reasons referred to later. This plot exhibits a much greater uniformity than Fig. 5.

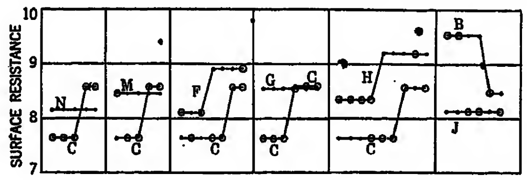

Fig. 8—Comparison of Types by Pairs upon a Surface Resistance Basis. Insulators not Washed Since Jan. 15, '29

Types A, B, K, L, AA, D are practically identical as to the range covered and are all types not washed since February 9, 1927. Types C, F, G, H, also have about the same range; M and N are restricted in range but the number of observations is small for each. The same qualification applies to type J; however, J is now in its proper place, not having arced-over unless it had the lowest resistance, which is as it should be considering its preferred position near the ground.

As a further test of the supposition that the surface resistance is a comparative measure of the resistance to arc-over, a direct comparison between types, taken in pairs, covering the whole period January 1, 1927 to July 19, 1929 is given in Figs. 7 and 8.

Comparing for instance Types A and B, each arc-over that has occurred upon either one of these is plotted, showing in the same vertical line the surface resistance of the two strings, the one that arced-over marked with a circle, and the one that did not, with a dot. Drawn lines connect points of the same type and do not represent any relation between coordinates. Type D has arbitrarily been assigned such a resistance per unit as would make it best fit the comparisons A-D and D-B, A and B being radically different designs. This arbitrary resistance of D turns out to be the same per unit as the calculated value for A.

If there were none of the accidental variations previously referred to and the surface resistance were an exact measure of the arc-over resistance, then the circle points would always be on the lower line. This is not the

case, considering those pairs of points where the higher resistance string has arced-over. The amount of the discrepancies is shown in Table III.

TABLE III
PERCENTAGE DISCREPANCIES OF FIGS. 7 AND 8

Pair of types considered	Average difference in surface resistances as per cent of the greater	Period of test
A–B	5.38	1– 1–27 to 7–19–29
B–C	7.07	" " "
A–D	6.15	" " "
D–B	2.76	" " "
A–L	4.17	" " "
B–L	4.40	" " "
B–K	8.60	" " "
K–L	8.22	" " "
B–J	0.00	" " "
N–C	3.72	1–15–27 to 7–19–29
M–C	1.28	" " "
F–C	5.80	" " "
G–C	0.12	" " "
H–C	8.23	" " "

It will be noted that the discrepancies are not large after all, considering the nature of the original data, and it is certainly impossible to assign to any one type rather than another any materially greater liability to arc-over when equal surface resistances of each are taken and exposed to the same conditions.

It therefore appears that the surface leakage resistance is a close measure of the ability of these types of insulators to stand up under such conditions as are found at Redondo and that there is no particular virtue in one shape over another, except in so far as it may afford more surface resistance and enable a fewer number of units to provide the total required.

There is a limit to the reduction in number of units per string imposed by ordinary dry and wet arc-over requirements and the danger of puncture when too few thicknesses of porcelain are used between line and ground. It would seem conservative to satisfy the ordinary line conditions as to number of units and then choose the type and perhaps greater number of units which will furnish the necessary surface resistance to suit the locality at the minimum of cost for both insulators and supporting structures.

TABLE IV
LIMITS REACHED IN ARC-OVER, LEAKAGE, AND RESISTANCE

Type	Max. number arced-over	Min. number not arced	Leakage arced-over	Distance not arced	Surface arced-over	Resistance not arced
A	16	17	172	183	10.41	11.06
B	10	11	200	220	10.62	11.69
C	9	10	164	183	8.59	9.55
D	16	17	176	187	10.41	11.06
E	7	8	231	264	8.14	9.30
F	11	12	182	198	8.92	9.73
G	12	13	158	171	8.58	9.30
H	11	12	171	186	9.21	10.04
J	7	..	231	..	8.14	..
K	12	13	198	215	10.17	11.01
L	11	12	209	228	9.99	10.89
M.	10	12	165	198	8.48	10.17
N	9	11	171	209	8.17	9.99

Note: Resistance per unit of "D" assumed equal to that of "A".

The final results of the elimination contest are shown in Table IV.

It is seen that strings having a surface resistance of from 9.99 to 10.62 have arced over, these strings having gone through the whole period of the test from 1-1-27 to 7-19-29 without being artificially washed, but that the strings washed 1-15-29 had in competition with them arced-over resistances of from 8.17 to 9.21, showing to some extent quantitatively how the washing done by natural rains compares with careful artificial cleaning. It further seems that a string with surface resistance of 11.0 will satisfactorily insulate against a steady 150 kv. to ground for three years under climatic conditions similar to those encountered at Redondo.

Acknowledgments are due practically all the insulator manufacturers for their ready response with samples of "fog type" insulators without which it would have been impossible to arrive at such definite results.

Conclusions

1. Insulators may be compared, as to their ability to withstand arc-over under spray and fog conditions, by their surface leakage resistance, calculated as the line integral of length divided by circumference along the shortest surface path from cap to pin.

2. There is no virtue in any particular shape except as it provides surface leakage resistance.

3. One insulator string will not consistently arc-over in preference to another unless its surface leakage resistance is less than 80 per cent of that of the other.

4. A surface leakage resistance of 11.0, in inch units, per string, appears sufficient for a steady voltage of 150 kv. to ground with conditions as at Redondo, Calif. On a line, allowance may have to be made for surges.

5. It has been found practical to clean some insulators, while energized, with a water spray and thus use a smaller number of units than would otherwise be safe.

An investigation of concentric and parallel duplex types of trailing cables made by the Bureau of Mines engineers leaves no doubt as to the greater relative safety of the parallel duplex cable for use on bureau-approved equipment, and it is hoped that after a careful study of the matter presented as a result of these investigations, the industry will arrive at the same conclusions and take steps to use the safest type of cable.

Field inspections showed that from the standpoint of reeling there is some preference for concentric cable. However, at mines where reeling difficulties have been overcome it was shown that if proper spooling devices are used practically no trouble is experienced in reeling parallel duplex rubber-sheather cable.

Applications to Mining Work

ANNUAL REPORT OF COMMITTEE ON APPLICATIONS TO MINING WORK*

To the Board of Directors:

In the past many criticisms have been made against the mining industry as being backward in modern developments. Certainly such criticisms are no longer justified to the same extent as a decade or two ago.

During the past year there have been many developments of electrical apparatus for mining work and the operators have not disregarded the applications offered. In fact, the operators have sought relief in every possible way to reduce operating costs. Over development during the war has not been absorbed by increased consumption of coal. This is largely due to rapid improvement in efficiency in large electric power plants, electrical interconnection, and in improved railroad performance.

Metal mines have been similarly affected from over-development and lack of increased demands.

It is generaly predicted that both coal and metal mining are entering a new era of development. Further mechanization is considered as a solution to the problem of cost reduction. Mechanization implies further electrical application to all types of mining equipment.

A few years ago there was considerable discussion on superpower systems. Without a great deal of publicity these superpower systems have developed until now practically every industrial and mining field is served from high-voltage interconnected lines receiving energy from large efficient power plants. Thus it is logical that the major part of the further electrification and mechanization of mines will be served from the electric utilities.

Hoists. Due to high cost of equipping shaft mines with electric hoists the change over from steam to electric is slow. One such change over a medium capacity mine is worthy of note, not for its size but for the rapid cycle. A 750-kw. synchronous motor-generator set supplies an 850-hp., 116-rev. per min. motor through Ward Leonard control.[1]

The hoist operates in balance and is designed for 230 trips per hour from a depth of 282 ft., with a maximum rope speed of 3300 ft. per min. The cycle allows for 5 sec. acceleration, 1.65 sec. full-speed running, 5 sec. retardation, and 4 sec. caging. Actual performance of 258 trips per hour has been attained by reducing the caging or stop period to two sections.

The motor-generator set is remote-controlled from the operator's platform. No auxiliary hoist motor is provided. The hoist is controlled through master controller and time limit relays for both acceleration and retardation.

In the mountain mines, a-c. motors have been applied for control and regenerative braking to control heavy descending loads previously handled by large drums and mechanical brakes. The power saving is appreciable and safety of control is valuable.

Fans. Synchronous motor drives for fans have been applied in sizes up to 500 hp.[2] Increased efficiency and improved power factor are accomplished.

Continued applications of automatic starters for fan motors have proved desirable to reduce to a minimum the delay in the restarting of fans after power interruption.

Motor-Generator Sets. Automatic substations for motor-generator sets have increased in number both to save in labor of attendance and to provide better service for supply of direct current to remote load centers.

Automatic power-factor control on synchronous motors has been accomplished on several sets.

Cleaning Plants. With the mechanical loading of coal being accomplished and with more discriminating buyers of coal, the industry has turned to mechanical cleaning. Several large bituminous coal cleaning plants were completed during the year.[3] Thus, the soft coal industry is approaching the practise of the anthracite breakers. These wet washing plants use around 150 motors of various sizes, aggregating some 1200 hp. connected load. Texropes or V-shaped multiple belts, permit of standard motors in most applications to secure proper speed reduction in short space. Three such plants on one public utility service add a very desirable day load.

Shovels. In metal mining the 3-, 4-, and 5-yd. electric shovels using shunt motors and Ward Leonard control continue to be installed to effect economies.

Additional 15-yard stripping shovels, weighing 1550 tons, and carrying motor-generator sets with 1500-hp. synchronous motors continue to be installed.[4]

Improved rubber covering for trailing cables has made these safer and more dependable. They usually carry 4000 volts, three-phase with a fourth wire for ground. Occasionally when blasting, these cables are damaged. Field vulcanizing has been perfected so that the outer covering is repaired so well that it will stand up through

*COMMITTEE ON APPLICATIONS TO MINING WORK:

Carl Lee, Chairman,

A. R. Anderson,	G. M. Kennedy,	F. C. Nicholson,
F. N. Bosson,	R. L. Kingsland,	W. F. Schwedes,
Graham Bright,	A. B. Kiser,	F. L. Stone,
M. M. Fowler,	W. H. Lesser,	E. B. Wagner,
E. J. Gealy,	John A. Malady,	J. F. Wiggert,
L. C. Ilsley,	C. H. Matthews,	C. D. Woodward.

1. Equipment furnished by General Electric Co. and installed at Peabody Coal Co., Mine 53, Springfield, Ill.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Printed complete herein.

2. Installed at Chicago, Wilmington, and Franklin New Orient mine, West Frankfort, Ill.

water and oil the same as the original cable, thus saving a great deal on replacement costs.

Slushers. Metal mines have almost completely adopted motor-driven underground slusher machines to replace air-driven machines.

Locomotives. One manufacturer has developed roller-bearing application to motor support on axles to maintain the gears in exactly correct mesh.[5] Experience in the field has not yet proved whether this will be acceptable practise.

Heavy service due either to large locomotives or very frequent travel of locomotives has led a number of mines to go to 6/0 trolley wire instead of 4/0.

Mining Machines. The manufacturers of mining machines have brought out improved track-mounted cutters (Fig. 1). These can be built to cut at any height in the coal seam that is required. These machines consist essentially of a heavy frame mounted on trucks containing traction motor and a swinging section pivoted at the front end of frame. This section carries the motor gearing, raising, lowering, and tilting mechanism, and the cutter bar and chain proper. The advantage of this type cutting machine over the breast machine and short-wall machine is that no unloading or loading of cutting machine proper is required. This feature elminates most of the manual labor, and through higher power and saving of time enables the operator to practically double his productivity. One make of machine is equipped with a drill so that the same crew can drill for the blasting.[6]

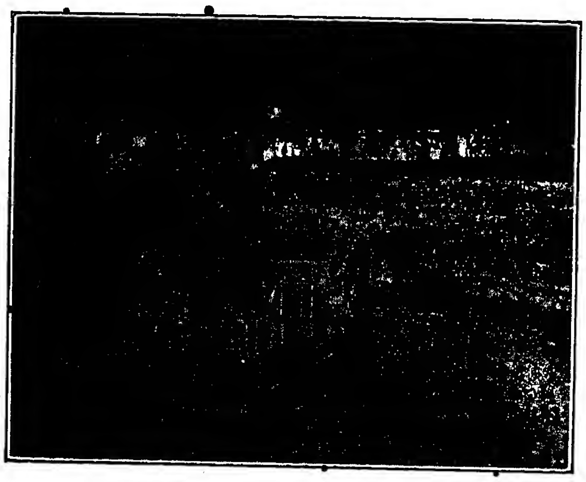

Fig. 1—Track-Mounted Bottom Cutter

In cutters for coal seams less than 30 in. high, it is difficult to place all controls convenient to the operator. One manufacturer has partially overcome this by applying contactor control to the machine. This control is of the "permissible" type construction, having been worked out to meet the tests of the Bureau of Mines.[5]

A recently developed machine is the hitch cutter.[7] This is a very special type drill to cut hitches in sides of rooms of coal mines to enable timbering to be carried to the face without interfering with cutting and loading machines This should materially reduce accidents at the coal face.

Loading Machines. One type of loading machine, usually called pit-car loader has been extensively installed (Fig. 2). Approximately 2000 have been placed in service. They consist of short-drag type conveyer driven by ½- to 7½-hp. motor. In this machine coal is shoveled onto the loader which discharges into mine car.

Fig. 2—Pit-Car Loader

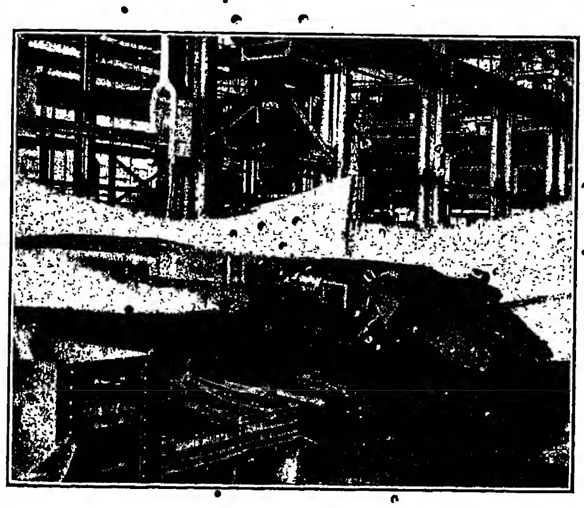

Fig. 3—Tank Tread Loader

Full mechanical loaders of several types have been improved and are coming into more general use (Fig. 3). These vary in design, using from one to eleven motors,

3. Pittsburgh Coal Co., Pittsburgh, Pa.
4. The United Electric Coal Co. at DuQuoin, Ill.
5. Jeffrey Manufacturing Co.
6. Sullivan Machinery Co.
7. Goodman Manufacturing Co.

having from 15 to over 100 connected horsepower. Reports indicate that approximately 3 per cent. of the soft coal mined in 1927 was loaded mechanically and most recent reports indicate over 22 per cent of coal mined in Illinois was loaded by mechanical and pit-car loaders.

Blasting. Continued experiments in smokeless shooting of coal have been made.[8] In this a gas is compressed to high pressure in the cartridge, then fired by means of fuse in heavy detonation or heating element. This fuse requires about 100 amperes at 180 volts to set off heating element.

Telephones. One company installed a complete system, using lead-covered pair in conduit laid in the floor of the mine.[9] In rapid hoisting, the caging is limited to 1½ or 2 sec. This does not permit the check puller to safely detach the identification checks. Several mines overcame this by installing loud speaking telephones between top and bottom.[10] The bottom man pulls the check and telephones the weighman giving him the number of the check.

8. Cardox.
9. Youngstown Sheet and Tube Co., Dehue, W. Va.
10. Peabody Coal Co., Mine No. 8, Tovey, Ill.

Switch Throw. An electrically-operated switch throw has been successfully applied to mine switches.[11] This eliminates the danger of having these throwed by hand. Also signal lights are worked in conjunction with the throw.

Welding. Electric arc welding is becoming more common for repair work. It is almost universally used for welding rail bonds. This year has brought a new use in the welding of a very hard special metal to the tips of mining machine bits, to produce ten times the wear.[12]

Safety Work. The Bureau of Mines continues to test all types of equipment to be used in gaseous mines. They have now placed their stamp of approval on 30 types of motors.

The approved cap lamp with greatly increased illumination is being rapidly adopted.[13] Over 30,000 of this type have been placed in use. A new cap lamp with lead battery and dry electrolyte has been developed.[14] This should reduce accidental burns from electrolyte.

11. Mines Equipment Co., St. Louis, Mo.
12. "Blackor."
13. Edison Models E. & F.
14. Concordia.

Audio-Frequency Transformers

Voltage-Ratio Characteristics Determined by the Low-Voltage Cathode Ray Oscillograph

BY PAUL KLEV, Jr.[1] and D. W. SHIRLEY, Jr.[1]

Synopsis.—*The usual method of determining the voltage ratio of audio-frequency transformers employs a three-element vacuum tube in the circuit. Due to the fact that the results are a combination of both transformer and vacuum tube characteristics this method is not entirely satisfactory. This paper describes a new method, using a low-voltage cathode ray oscillograph, by means of which the voltage ratio of a transformer is determined independent of any other apparatus This newly developed method is accurate and simple in operation, and gives the actual characteristics of the transformer for all frequencies and d-c. components. The ratios of several makes of transformers were determined over a frequency range of 20 to 10,000 cycles and at different degrees of magnetic saturation. The results indicate that the ratios are very good between frequencies of 40 and 3000 cycles. Saturation within the usual operating limits was found to have little effect. The method developed was found to be exceptionally good, as the results are accurate and are readily reproduced. However, precautions must be taken to eliminate stray fields which may influence the tube unless properly shielded.*

Introduction

In the last few years, the radio industry has experienced an exceptional growth. Accompanying this growth is the desire on the part of the public for better reproduction of voice and music; and closely connected with this is the amplification of audio frequencies. This in turn calls for audio-frequency transformers which have good characteristics; that is, good voltage ratios over a wide range of frequencies. This being the case, it is important to be able to determine the characteristics of audio-frequency transformers independent of the apparatus which would influence the results. This paper describes a method by means of which the voltage ratio of transformers may be determined entirely independent of all other equipment.

1. Students in Electrical Engineering at Oregon State College.
This paper received the A. I. E. E. National Prize for Branch Paper (year 1928).

Presented before the Portland Sections of The A. I. E. E. and The N. E. L. A., May 25, 1928.

Method of Obtaining Data

Under actual operating conditions, an audio-frequency amplifying transformer has impressed on the primary a direct current with a superimposed alternating current of audible frequency. The d-c. component of this pulsating current largely determines the point on the saturation curve at which the transformer

operates, and therefore may influence the voltage ratio at various frequencies. Before attempting to determine the voltage ratios, the magnetization curves of the transformers were obtained so that values of direct current within the working range could be used.

The magnetization curves were determined with a circuit arrangement as shown in Fig. 1. The data were

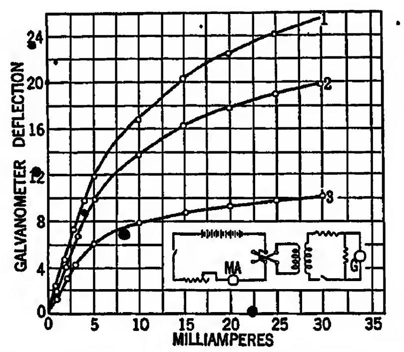

Fig. 1—Saturation Curves for Transformers Tested

Curve 1 .... Transformer A
Curve 2 .... Transformer B
Curve 3 .... Transformer C

obtained by adjusting the direct current in the primary to certain values and then reversing the switch shown. The resulting galvanometer deflections, also shown plotted in Fig. 1, indicate the degree of saturation of the core. The curves in Fig. 1 should not be regarded as indicating the relative degree of saturation since different galvanometer shunts were used; also, the number of secondary turns and other transformer constants

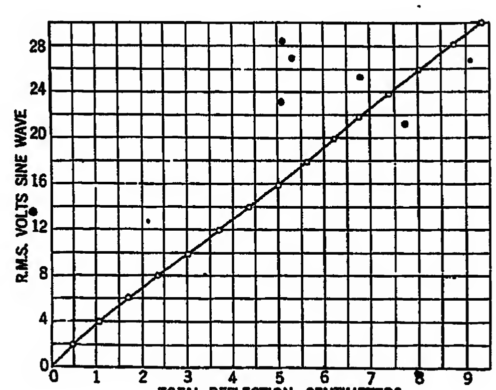

Fig. 2—Calibration Curve for Western Electric Type 324-A Low-Voltage Cathode Ray Oscillograph

Anode voltage 312, using deflector plates *PY*

were not the same for each. This figure does show, however, the shape of the magnetization curves and thus indicates the range of d-c. values which may be used in the primary.

A Western Electric 324-A low-voltage cathode ray oscillograph tube was used for measuring the primary and secondary voltages. Since this low-voltage oscillograph is comparatively new, a brief explanation of its construction and operation will be given. The general arrangement of parts is shown in Fig. 7.

A stream of electrons is projected from the heated filament on to the fluorescent screen where it produces a bright spot. This electron stream may be deflected by subjecting it to an electric or magnetic field, and the position of the spot at any time is an indication of the strength and direction of the field at that instant. If properly connected, these deflecting fields will vary with the current or voltage under observation and thus electrical phenomena are made visible on the screen.

Due to the fact that the moving element consists of a stream of electrons, the cathode ray tube is practically free from inertia or resonance effects. This feature makes the frequency limits at least as high as the upper radio frequencies, which are far beyond the highest frequencies used in these tests. Another feature which makes this tube very desirable is its accuracy. This may be shown by the calibration curve, Fig. 2. As can be seen, the maximum deviation of any point from the experimentally determined calibration curve is about one-half of one per cent.

Due to the action of the earth's magnetic field and

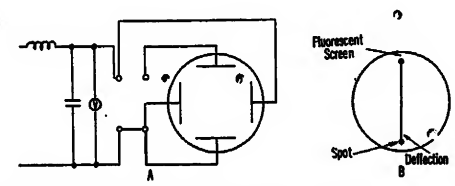

Fig. 3—Circuit Used for Calibration of the Cathode Ray Oscillograph

other stray fields, and partly because of the lack of mechanical alinement of the tube parts, the fluorescent spot may fall several centimeters from the center of the screen. It is necessary to bring the spot to the center, and here this was accomplished by means of a large electromagnet mounted upon a movable platform. The spot may be brought to the center of the tube with a small magnet nearer the tube; however, less distortion results if a strong magnet is used some distance away. By moving the position and regulating the value of current in the electromagnet, the spot was brought to the center of the tube and at the same time the value of current supplied was noted. This current value was held constant for all tests.

Due to the fact that the deflector plates are not the same distance from the screen and that they are not a given distance apart, it is necessary that the tube be calibrated for quantitative results. The circuit used for calibrating the tube is shown in Fig. 3A. A known sine wave alternating voltage was applied to the deflector plates used and the length of the deflection, which is a straight line, Fig. 3B, on the fluorescent screen was measured. Various values of voltage were impressed and the corresponding deflection observed. The calibration curve, Fig. 2, was then drawn by plotting

effective (r. m. s.) volts as ordinates and total deflection in centimeters as abscissas.

Every precaution was taken to eliminate errors in obtaining data for the calibration curve of the cathode ray tube. The current supplied to the electromagnet, used to compensate for the earth's field, was held constant during the entire test. Also, the effects of stray fields were eliminated; first, by using closely

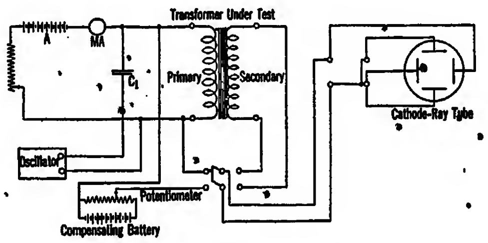

Fig. 4—Circuit Used for Determining Audio-Frequency Transformer Ratios Using the Low-Voltage Cathode Ray Oscillograph

twisted parallel conductors for all current-carrying circuits; and second, by shielding the tube from electrostatic fields. The calibration varies with the anode voltage and thus this voltage was held constant for all tests. For calibrating, the wave form of the applied voltage should be a sine wave, and to obtain this as nearly as possible, the harmonics were practically eliminated with a filter as shown in Fig. 3. An oscillogram of the voltage was made and showed the wave to be a sine wave with practically no harmonics, less than two per cent deviation, and a crest factor of practically 1.414. The calibrating voltage was obtained from a three-phase 220/127-volt alternator. All instruments used in making current and voltage measurements were carefully calibrated against accurate standards.

The connections used for measuring the transformer ratios is shown in Fig. 4. As indicated in the diagram, a battery "A" was connected through a resistance and a milliammeter to the primary of the transformer. This battery supplied the component of direct current which is present in the primary of all audio-frequency transformers. The variable-frequency voltage was obtained from a Western Electric 8-A oscillator which had a frequency range from 100 to 50,000 cycles and a good wave shape. The voltages at frequencies below 100 cycles were taken from an alternator driven at different speeds so as to generate the frequency desired. The voltage wave of the alternator was practically a sine wave. A condenser, C 1 Fig. 4, was connected in series with the oscillator to prevent the direct current from entering the oscillator circuit. To facilitate making measurements, a double-pole double-throw switch was connected to the primary and secondary of the transformer and to the oscillograph, as shown in Fig. 4.

The voltage drop due to the d-c. component in the primary of the transformer caused the electron stream to be thrown entirely off the fluorescent screen, and consequently, some means had to be devised to compensate for this deflection. A method was finally adopted which used a compensating potentiometer, as shown in Fig. 4. This potentiometer voltage was connected to oppose the constant component of the pulsating voltage that would otherwise be applied to the cathode ray tube. By properly adjusting this compensating potentiometer, the spot was brought to the center of the screen. As a test to determine whether the constant component was balanced, the deflector plates were short-circuited. If the spot remained stationary when this was done, no constant voltage was impressed on the oscillograph. The position of the compensating potentiometer and the battery in the circuit has no effect on the oscillograph, but merely acts as an additional load on the oscillator.

As previously explained, the oscillograph is very sensitive to stray fields, and in view of this fact, all current-carrying leads were twisted. The leads from the switch or transformer to the oscillograph should be as short as possible and not twisted. The reason for this is that at high frequencies, the charging current due to the capacitance of long twisted wires acts as a load on the transformer when measuring the secondary voltage. It was found that if long twisted leads were used, the voltage ratios were lower for frequencies above 2000 cycles.

Several types of transformers were received and three transformers which were considered to be representative were chosen for the tests. The ratio of transformer A was 3 to 1; the core is of silicon steel and is extra large, the entire transformer weighing very nearly five pounds. Transformer B has a ratio of 2.7 to 1 and weighs about one and three-quarters pounds. Transformer C has a ratio of 5 to 1, and weighs approximately two pounds.

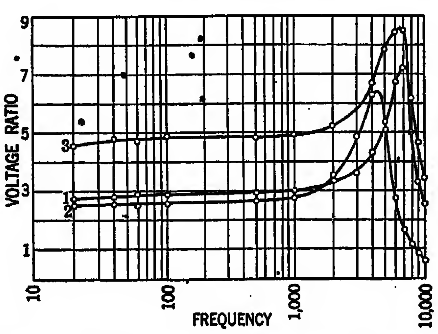

Fig. 5—Voltage Ratio of Transformers Tested, Primary Current Three Milliamperes

Curve 1..Transformer A
Curve 2..Transformer B
Curve 3..Transformer C

All of these transformers are standard makes and are used extensively in radio work. Other information regarding their construction was not available at the time these tests were made.

From a study of the magnetization curves, (Fig. 1) and a general knowledge of the primary currents usually found in radio receivers, it was decided to use currents of one, three, and five milliamperes for the transformer tests.

In making all measurements, the value of current in the electromagnet producing the compensating field was adjusted to the predetermined value and held constant. The direct current in the primary was then adjusted to the desired value. As previously mentioned, the d-c. component of voltage in the primary must be balanced so that the reading could be made in the center of the oscillograph screen. This was accomplished by adjusting the potentiometer across the compensating battery until the spot remained stationary when the deflector plates were short-circuited. A voltage of the proper frequency was then applied to the primary of the transformer and its magnitude adjusted to give a reading of primary and secondary voltage on the working range of the fluorescent screen.

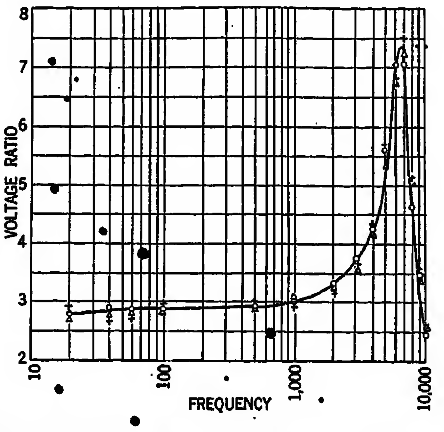

Fig. 6—Voltage Ratio of Transformer *A* Using Various Values of Primary Current

O Primary current—1 milliampere
Δ Primary current—3 milliamperes
+ Primary current—5 milliamperes

In measuring the length of the deflections, a piece of thin paper was placed over the fluorescent screen and the maximum deflections of the visible spot were marked for both primary and secondary readings. To be sure the readings were accurate, each reading was checked. In a similar manner, other readings were made using different frequencies and various degrees of core saturation for each transformer tested.

Discussion of Results

The curves, Fig. 5, show the voltage ratios of transformers *A*, *B*, and *C* with a primary current of three milliamperes. These curves show that in all cases the transformer ratios are very good at frequencies between 40 and 3000 cycles. The curves also show that "peaks" occur within a range of frequencies from 4000 to 7000 cycles. Although each transformer had a different ratio, transformer *C* (curve 3) seems to have the best characteristics as the per cent increase in ratio at 3000 cycles is less than for either of the other two. However, transformer *A* (curve 1) is practically as good as transformer *C* in this respect.

The curves in Fig. 6 were made for transformer *A* to show the effects of saturation. Due to the fact that the curves would fall so close together, only one curve has been drawn, and points have been shown only for the other two curves. The curves seem to indicate that the degree of saturation has little effect on the transformer ratio. However, the fact that these curves were taken at degrees of saturation below the knee of the magnetization curve must be considered, and these results hold for such values only.

Again referring to Figs. 5 and 6, the curves indicate that in all cases the points are uniform and closely follow the curve. This indicates not only that the measurements were accurately made, but also that this method is satisfactory.

Conclusions

The major conclusions to be drawn from this study are as follows:

1. The method here outlined for determining transformer voltage ratio is simple, direct, and accurate. The error in making individual measurements is not more than one-half of one per cent.

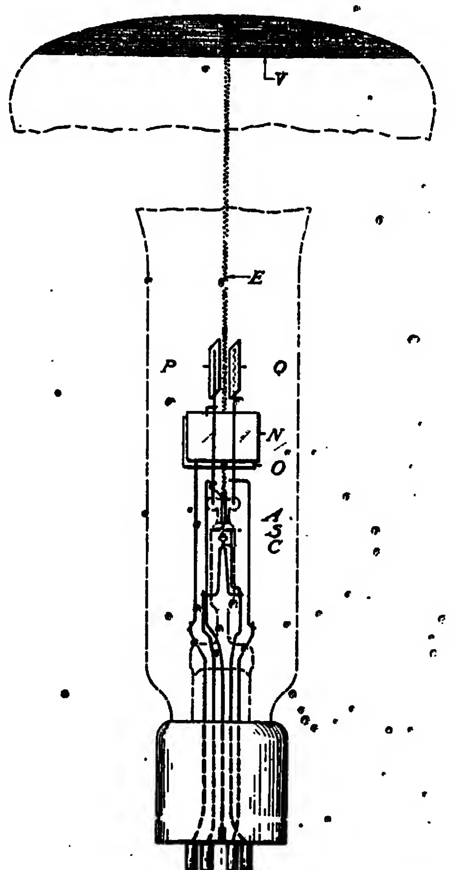

Fig. 7—Schematic View of the Cathode Ray Tube

Key,— *V*—Viewing screen
P. *Q*.—Upper deflecting plates
N. *O*—Lower deflecting plates
A—Anode
S—Shield
C—Cathode
E—Stream of electrons

2. After the circuit is once adjusted, measurements can be made very quickly. With a little experience,

two men can obtain data for a curve in about 15 min.

3. To insure a high degree of accuracy, stray fields must be eliminated by doubling all current-carrying conductors; by using leads from the transformer to the oscillograph which are as short as possible, and by keeping them far apart; and by shielding the cathode ray tube. Furthermore, the compensating field current and the tube anode voltage must be maintained at constant values.

4. The results obtained from the transformers tested indicate that the best working range is between 40 and 3000 cycles per sec.

5. Below the knee of the magnetization curve, the degree of core saturation did not materially affect the voltage ratios over the entire range of frequency from 20 to 10,000 cycles.

The faculty of the Electrical Engineering Department at Oregon State College deserves mention for its hearty cooperation in connection with this study. Considerable credit is due F. O. McMillan, Associate Professor of Electrical Engineering, and Messrs. A. L. Albert and E. C. Starr, Instructors in Electrical Engineering, for their assistance and many valuable suggestions.

Abridgment of

Automatic Stations

ANNUAL REPORT OF THE COMMITTEE ON AUTOMATIC STATIONS

To the Board of Directors:

This terminates the second year of the existence of this committee. The field of action in which this relatively new committee finds itself is so broad and has so many inviting byways that it has been difficult to outline the work. The engineering connection with the application of automatic control is so fascinating as to result in so many new ideas being steadily developed that sometimes the fundamentals are almost overlooked. In the following report, this committee attempts to outline some of the development and offer suggestions which are intended to benefit this branch of the industry.

Scope

The scope of this work covers automatic, and partially automatic, generating stations and substations, the committee having complete jurisdiction over all apparatus associated with such stations. In addition, it has jurisdiction over systems of remote dispatching, control, indications, etc., associated with the industry. The committee is interested in the dissemination of the knowledge and experience already gained in the design and operation of such equipment and combinations thereof, in order that this branch of the industry may be more fully developed.

Economical Construction

The developments of the year indicate a general tendency to take advantage of the economical construction possible with the use of automatic stations. It is still hard to realize the radical difference in station arrangement and set-up between the old firmly rooted manual system of operation and modern automatic operation.

It is believed that one of the most radical and economical changes in station arrangement has been the elimination of the continuous switchboard. When this is studied it is found that there is no longer a necessity for assembling all of the control wiring from remote parts of a station at one point at the expense of thousands of feet of wire and conduit.

The above is particularly true in a-c. substations and hydro station applications where the details of control can and properly should be located as near the equipment controlled as is consistent with good fire protection and safety. It is now becoming common to see control panels located in various places throughout a station close to the equipment controlled, thus saving considerable in wire, conduit, and hazard.

Another saving has been realized from the reduction in size and, in some cases, the complete elimination of heating plants.

Ventilation has also been reduced, as in many cases a considerable amount of air over and above that actually essential to station apparatus for the comfort of the operating employes was required.

The problem of station location has been eased somewhat by the advent of automatic control, as stations can be located now in places where it would be almost impossible to keep operating men on the job on account of the absence of what might be considered the amount of daylight, pure air, water, etc., necessary for the continuous maintenance of human beings.

*COMMITTEE ON AUTOMATIC STATIONS

W. H. Millan, Chairman,

P. H. Adams,	H. C. Don Carlos,	O. Naef,
Caesar Antonioho,	P. E. Hart,	E. W. Seeger,
L. D. Bale,	Joseph Hellenthal,	Roy M. Stanley,
C. A. Butcher,	Chester Lichtenberg,	L. J. Turley,
M. S. Coover,	S. J. Lisberger,	F. Zogbaum.
	G. H. Middlemiss,	

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copy upon request.

Research and Development

Research during the past year has brought forward many improvements in detailed apparatus which are contributing much to simplify the problems of applications. Careful analysis of operating records disclosed the need of more simple means for the adjustment of equipment to meet a wide range of applications, particularly for the calibration of relays. Much has been done in this connection with the result that not only have improvements in relays simplified matters of calibration, but by extending the range of applications, the number of types of relays required has been reduced, thus greatly simplifying routine inspection and maintenance.

Simplified and improved supervisory control and remote metering systems have been produced as a result of experience with several very successful schemes in numerous applications.

Some work has been done in the development of devices for recording operations, quantities, etc., on charts, but this appears to be one of the weakest points in automatic development.

Simplified schemes of control for the automatic switching of rotating apparatus looking toward reduction in the number of moving parts are being tried out. The economics of application are being given a great deal of study. On a number of metropolitan street railway properties, the items of power consumption from the generating stations to the car wheels are being carefully analyzed. Operating voltages best suited to given areas will be selected and means for automatically or remotely controlling the substation apparatus for proper adjustment of the voltage to operating conditions will be provided.

Operating Reports and Inspection

The predecessors of this committee have stated that the art would advance much more rapidly if more operating engineers would avail themselves the opportunity at Institute meetings to tell, through papers, of their individual experiences and freely taking part in discussion. It is felt that in this way the annual reports of this committee will be more representative. With this idea in mind, your committee has this year sent out questionnaires attempting to gather operating, maintenance, and inspection data from a wide field of experience covering a variety of applications. While these questionnaires may be considered a burden by some, this committee feels that a large number of engineers are vitally interested in the subject and are willing to furnish the data requested to the end that the art may be more universally applied and incidentally improved. Some answers to the questionnaire have been received, but not a sufficient number to present a recapitulation in the pages of this report. This committee intends to turn this partly finished work over to its successors with the earnest recommendation that they carry it forward.

Inspection and maintenance of automatic plants may be catalogued into two general classifications,—quality and quantity;—depending entirely upon the continuity of service expected and demanded of the automatic plants and by the individual managements.

The word "maintenance" is used advisedly in view of the fact that inspection and maintenance are so closely allied at times as to be almost inseparable.

Past and present experience as reported by the various operating engineers seem to disclose the fact that to properly function, automatic equipment should be given casual and periodical inspections. These inspections vary according to the needs and conditions of the individual installation and the severity of service. The casual inspections on metropolitan systems as reported are made as often as two hours apart during the heavy hours of the day, and two or three days apart on other systems and conditions.

These inspections usually consist of observing the functioning of equipment in service, overheated contacts, graphic chart clocks for time, inking, bearings, overheating, ventilation, etc. For stations outside of metropolitan districts the casual inspections are likewise reported as being made daily on some systems, and weekly on others, ranging in the average of two or three times a week, with a tendency to make fewer inspections when the stations are equipped with supervisory control. The actual time required to make a casual inspection is much less than the traveling time.

Standards

Standards for Automatic Stations (No. 26) were adopted and issued in 1928. It was realized that in view of the rapid progress of this branch of the industry, it would be necessary to revise these standards from time to time. A subcommittee has worked out some desirable changes which are not sufficiently voluminous to warrant a revision of the Standards as published. however this committee will add to this group of changes from time to time, until it is felt that it is worth while to present them to the Standards Committee with recommendations.

Bibliography

With the idea that a complete bibliography of "Automatic Station" literature would be of inestimable value to the electrical engineer, this committee published as an appendix to its report of last year a complete bibliography up to the date of this report. A supplement covering literature published since the last report and up to March 1, 1929 is included as an appendix to this report. Acknowledgment and thanks is hereby given to the Main Library, of the General Electric Company for this service.

Abridgment of

Production and Application of Light

ANNUAL REPORT OF COMMITTEE ON PRODUCTION AND APPLICATION OF LIGHT*

To the Board of Directors:

Introduction

The report of the Committee on Production and Application of Light calls attention to the outstanding advancements and trends in the art of lighting by electricity. Material used in the compilation has been furnished not only by members of the committee but by other authorities in various fields.

Production of Light

As was the case a year ago, most of the developments in production of light during the past year have been of the nature of improvements rather than radically new devices or methods.

Incandescent Filament Lamps

Standard Multiple Lamps. The 60-watt inside-frosted lamp is now made in the A21 bulb, as is also the 50-watt. This simplification is of advantage not only to the manufacturer but to the user.

There has been brought out a 75-watt inside-frosted bulb lamp in the A23 bulb, having the same dimensions as the 100-watt lamp.

Special Multiple Lamps. The 10-watt 115-volt in the C9¼ bulb has been improved in appearance and a new 25-watt 115-volt T6½ bulb lamp has been announced. This lamp is for use in showcase and other small reflectors.

Railway Signal Lamps. Several types of lamps have been standardized by the Signal Section of the American Railway Association—these have the popular C-2 filament form.

General application	Volts	Amperes	Watts	Bulb	Base	Filament	Rated aver. life (hours)
Night indication, including switch lamps, somaphores, wig-wag highway crossing and crossing gates	3.5	0.3		S-11	S. C.	C-2	1000
	10.	0.25		S-11	S. C.	C-2	1000
	13.5	0.25		S-11	S. C.	C-2	1000
	10.			S-11	S. C.	C-2	1000
Day and night indication including light signals and highway crossing flashing signals	10.		5	S-11	S. C.	C-2	1000
	10.		10	S-11	S. C.	C-2	1000
	10.		18	S-11	S. C.	C-2	1000

Street Series Lamps. There has been further standardization of bulb sizes for street series lamps with resultant greater flexibility in manufacture and in use.

Aviation Lamps. The ideas of illuminating engineers on the subject of floodlighting for aviation landing fields crystallized during the year to the point where it was impossible to standardize a group of four lamps for this service. These are the 1500-watt 32-volt T-24, the 3000-watt 32-volt GT-38, the 5000-watt 115-volt G-64, and the 10,000-watt 115-volt G-80 airport floodlighting lamps.

Motion Picture and Sound Recording Lamps. The introduction of motion pictures accompanied by sound required the development of a number of new tpyes of incandescent lamps designed for use both in the studio where the pictures are taken and in the projection apparatus. In the studio, in addition to the standard general lighting lamps, three high-wattage lamps especially designed for this service are used. These are the 2000-watt 115-volt G-48 bulb spotlight, the 5000-watt 115-volt G-64 and the 10,000 watt 115-volt G-80.

Colored Lamps. Light's Golden Jubilee, celebrated this year to commemorate the 50th anniversary of the incandescent lamp, is made more colorful by the use of inside-colored lamps, a process developed during the year. By this process, the coloring material is sprayed on the inside of the bulb walls instead of on the outside. Thus the coloring material is protected from the weather, is rendered permanent and proof against fading or scratching, and the outside of the bulb is left smooth to retard the accumulation of dirt and permit easy cleaning.

Bases, Sockets, and Adapters. There has been brought up a mogul prefocused base, similar to the medium screw base brought up on last year's report. This is used for various spotlight lamps, floodlight lamps, airplane headlight lamps and airway beacon lamps. New vibration resisting adapters have been developed for use in lamp sockets in order to give still

*PRODUCTION AND APPLICATION OF LIGHT:

B. E. Shackelford, Chairman, Westinghouse Lamp Co., Bloomfield, N. J.
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W. T. Dempsey, A. S. McAllister, W. T. Ryan,
Lewis Fussell, G. S. Merrill, W. M. Skiff,
G. C. Hall, P. S. Millar, C. J. Stahl,
L. A. Hawkins, G. H. Stickney.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

further protection to lamps burning under conditions of extreme vibration.

Voltage Standardization. It is common practise to refer to the lighting circuit voltage as "110 volts" but it may surprise many to learn that 110-volt lamps comprised only 8.1 per cent of the total number in the 100- to 130-volt range sold during 1928. Approximately 48 per cent were rated at 115 volts and 39 per cent at 120 volts. The remaining 5 per cent were scattered among the other voltages in that range.

Gaseous Conductor Lamps

Mercury Arc Lamps. To meet the demand for industrial lighting units giving a radiation more nearly equivalent to direct sunlight in the effect on general health, mercury arc tubes have been made up in forms identical with those used for industrial lighting, but in glass of slightly higher ultra violet transmission.

The rapidly expanding field of application of quartz mercury arcs in both therapeutic and health lighting has brought forth a variety of new types of arc, all of them differing from older designs in minor mechanical details of construction and appearance only.

Neon Lamps. Smaller electrodes are being used than were formerly thought possible and lamps of higher current density are coming into greater use. New color effects have been obtained by means of filter glass tubing and by the use of different gases.

Hot-cathode low-voltage and negative glow socket type of neon lamps have undergone further development during the past year.

Induction Lamp. The electrodeless discharge in neon, in the form of an induction lamp, has undergone development during the past year and is being used experimentally as a light source for airway beacons. A three-in. clear fused quartz bulb incloses the luminous gas. The lamp under operating conditions has a brightness in excess of 40 candles per sq. cm. and when used at the focus of a 36-in. mirror, a beam candlepower of the order of 500,000 is obtained.

Carbon Arc Lamps. A number of types of arc lamps using impregnated carbons has been placed on the market for therapeutic use. While some of these are of the cheapest construction, others are very well made and provided with filtering glasses for proper ranges in the ultra violet spectrum.

Application of Light

Interior Illumination

Industrial Lighting. The past year has witnessed an increasing acceptance on the part of production managers of high levels of general illumination. Among the new lighting systems installed was a goodly number in which 15 to 30 foot-candles of general illumination are obtained; in some instances higher illumination values of 40 to 60 foot-candles over large areas have been found economical.

Following closely upon the acceptance and installation of these higher levels of illumination is an increasing interest in special lighting for specific jobs. Group lighting, a system in which the lighting units are located with respect to the machine groups, has been adopted in a number of plants, especially those where the location of the machine groups is fair'y permanent and in which the direction of light desired is constant.

The development of group lighting applications requires characteristic distribution curves of light which are necessary to obtain the greatest utilization over any given area; more and more attention is being paid to the control of light to fit these requirements.

Commercial Lighting

Mention was made last year that installations designed along modernistic lines were beginning to appear.

The merchant is always in search of the new to attract customers, and it is natural that he is one of the first to adopt the new school. The distinctive shops have given us some wonderful examples of the use of light for decoration and even the department stores under construction are decidedly modernistic in feeling.

The entrance and lobbies of the new office buildings are striking and generally lighted in such a way as to take full advantage of the potentialities of present day light sources.

Residence Lighting

The modernistic trend in home lighting equipment has made a vast stride in the past year. American manufacturers are offering many varieties of fixtures closely resembling the designs which European artists have been developing. Decorative portables, wall brackets, and center luminaries are designed with pronounced geometric plane surfaces representing in many instances an assembly of rectangles, triangles or squares of various light colored tints, plain shades, and artistic mixtures. These glass planes not only conceal the lamps from general view but also diffuse the light over a wide area, thereby creating a quality of illumination which engineers have been striving for years to introduce into the American home for wholesome lighting.

Light Ornaments. A few years ago the use of light simply for decoration was encountered only rarely. Now one scarcely passes a single gift shop which does not display one or more forms of light ornaments. During the past year American manufacturers have developed some very commendable types. These use cast figures against lighted background, translucent colored urns, cut crystal figures lighted from beneath, and even translucent porcelain.

Motion Picture Lighting

A census taken about the first of February shows that of some 60 or more pictures in the process of being photographed approximately 60 per cent were being made with incandescent lamps, an increase from 25 per cent as of July 1, 1928. The general practise of the studios has been to make their sound pictures

entirely with incandescent lamps and to restrict the use of other illuminants to the silent pictures.

The Universal Studio has recently completed the filming of the picture "Broadway," taken from the popular New York success of the same name. The largest indoor set ever constructed was used for the cabaret scene. This scene, together with several others immediately adjacent and really becoming a single large set, was lighted entirely with 4800 incandescent lamps whose wattage totalled 3,900,000. The largest part of this energy was employed in regulation motion picture photographic lighting equipment. There were, however, many thousands of lamps of lower wattage employed for decorative effects.

Installation Standards

For several years illuminating engineers have been feeling an increasing degree the limitation of inadequate wiring as an obstacle to the development of good lighting practise in commercial and industrial buildings. From a study of the problem it was concluded that this situation and other problems could best be met by cooperation on the part of central station lighting service bureaus with architects. In formulating a plan certain officials of the American Institute of Architects were consulted with gratifying response. Therefore in the Fall of 1928 a committee of the National Electric Light Association started in on a program of constructive effort. Two courses of instruction for central station lighting service engineers have already been held at which pertinent technical information was reviewed.

To express the adequacy features of wiring so that the illuminating engineer may plan proper lighting a set of model specification paragraphs has been prepared containing some new features which facilitate checking up on the wiring construction work.

A third phase of the program is a plan of advertising to emphasize to architects the importance of good lighting and to interest them in cooperation with the lighting experts of the central station companies.

Based on experience in Chicago, the Society for Electrical Development has adopted a simplified method of planning and figuring the lighting installation in accordance with present-day standards. This is known as the Franklin Red Seal Lighting Specification, the rules being published in pamphlet form and providing for all conditions ordinarily existing in that field.

Exterior Illumination

Street Lighting. Street lighting practise is progressing slowly but at a rate which with a few sporadic exceptions is inadequate to meet the rigorous demands of modern high speed traffic. The average light output of incandescent street series lamps sold during 1928 was 5.8 per cent higher than the output of such lamps sold during 1927 (Report of Lamp Committee, N. E. L. A.). This is one indication of progress, since the use of larger lamps suggests improved street lighting. Yet it is the general testimony of the best informed engineers that a marked advance not only in the amount of light produced for street lighting but also in the skilful application of that light is required before street lighting practise may be considered to be abreast of modern requirements.

The outstanding development in street lighting is the increasing recognition of the importance of a comprehensive street lighting plan prepared in coordination with city planning at large and particularly with regard to street traffic problems. The practise of classifying projected street lighting plans by stating the illumination required for streets of different character is also a growing tendency which promises a more definite and scientific treatment in the future.

It is coming to be recognized increasingly that the only thoroughly satisfactory solution of the automobile headlighting problem is to provide street or highway lighting sufficiently to permit safe and expeditious transit without the employment of powerful far-reaching headlights, and at least with depressed headlight beams. In the case of interurban highways, the problem of providing fixed lighting is receiving much attention. Where needed, enabling acts to permit counties and villages to provide for highway lighting are being sought.

Traffic Signal Lighting

In the year 1928 much was done towards standardization of traffic signals. The report of the Committee of the American Engineering Council on Street Traffic Signs, Signals, and Markings was finally finished and has been issued in pamphlet form. This report is very complete and does a great deal to lead to standardization of traffic signal practises. Very little change has occurred in traffic signals themselves since these had reached a very high state of development prior to 1928. During the year, however, traffic control apparatus took another step forward in that practically all manufacturers developed control apparatus for a full coordinated movement of traffic.

Portable Flasher. There is being brought out a portable electric flasher designed primarily for traffic warnings where kerosene lanterns have been extensively used. It has, however, many other possible uses in connection with both land and water traffic. Although the initial cost of the beacon is considerably more than that of oil lantern, its maintenance cost is so much less that in the long run, it provides the most economical warning signal.

Automobile Headlighting. Committees of the Illuminating Engineering Society and the Society of Automotive Engineers have been active during the past year considering such subjects as Specifications for Headlamp Mountings, Specifications for the Test of Rear and Signal Lamps, and Comments on the Existing Specifications for test of Headlamps of the dual beam type.

The outstanding achievement during the past year in

motor car lighting has been the adoption of fixed-focus construction for headlamps. Various investigations have shown that the principal cause of glaring lights has been improper focusing of the lamps.

Sign Lighting

The two schools of electrical advertising sponsored by the National Electric Light Association in the Spring of 1928 were so successful that it was decided to try out local schools in the geographic divisions. Three of these schools have already been opened, New England Division in Boston, Mass., Great Lakes Division in Chicago, Ill., and East Central Division in Cincinnati, Ohio. Others are planned for the Fall. The Society for Electrical Development, Electrical Advertising Section, is bringing out a Plan Book suggesting methods by which public utilities can stimulate electrical advertising.

Among the developments in sign lighting during the past year, should be mentioned the new S11 sign lamps supplied in colors and with the intermediate screw base, the so-called "Talking Signs" in a variety of sizes and the continued improvement in gaseous tube signs. Some of the latter are used in combination with incandescent lamps for very effective combined signs.

Lighting of Building Exteriors

Floodlighting is being used more extensively to bring out the architectural beauty of offices and public buildings at night. In the larger cities new buildings are generally erected with step-back construction at the higher levels and these offsets made the use of floodlighting particularly effective. Architects are also showing a greater appreciation of the value of floodlighting with the result that in some instances the exterior lighting of the buildings is considered at the time the designs for the building are made. Colored lighting is receiving more attention, and the combination of color and motion in what has been called mobile color lighting is unfolding new possibilities for attractive night displays in building decoration. There is a very decided trend toward the use of colored lighting either with or without motion as this type of lighting has much greater possibilities than the use of plain white light.

Lighting for Aviation

Beacons and course lights have been installed on approximately 9000 mi. of the national airways by the U. S. Department of Commerce, and about 2000 additional miles will be lighted by the end of June, 1929. Where course lights are mounted on beacon towers, when no landing field is near by they are equipped with a red color screen; when a suitable landing area is in the vicinity, with an amber color screen.

During the past year there has been great activity in equipping airports for night flying with a view to obtaining an "A" rating from the U. S. Department of Commerce, which has issued Aeronautics Bulletin No. 16 explaining the requirements in detail.

The retractable airplane headlight may be operated on the retracted position with beam pointing downward for pick-up and can also be used in any intermediate position to forward, where it is usually held when contact is made with the ground. The fixed headlights are usually stream lights in the wings to reduce air resistance. A smaller headlight with a 6-in. reflector has has recently been developed using a 100-watt 12-volt A-19 bulb lamp with intermediate profocused base. The subject of airplane headlighting is being studied by a committee of the Society of Automotive Engineers.

Lighting of Bridges and Tunnels

Since the opening of the Holland Vehicular Tunnel under the Hudson River, a new standard for the lighting of underground vehicular passageways has been established which is being followed by several similar installations, notably the Zion-Mount Carmel Tunnel in Utah and the Detroit Vehicular Tunnel between that city and Windsor. An item of interest may be recorded; namely, that higher intensities of roadway illumination without glare speeds up traffic very materially and quite directly returns a greater revenue from the investments in the complete structure. This same fact is now recognized in connection with bridge traffic as is also fairly well recognized the fact that bridge lighting should be of the order of two to three times the intensity of the connecting highways. The floodlighting of bridge structures, especially the approaches thereto, has resulted in a considerable beautification of water fronts incidentally affording greater safety to aviation pilots.

Underwater Lighting

Considerable interest has been displayed in the application of electric incandescent lamps to under water illumination. The 1000-watt, 115-volt, G-40 bulb special diving lamp which is self-contained and designed to be operated directly immersed in the water is standard equipment for all capital ships in the U. S. Navy. Luminous fountains have been constructed with light projectors mounted beneath water-tight glass plates or with separate water-tight self-contained projectors located in the water or at the base of the fountain jets. Various types of equipment are now available, some consisting of lamps mounted behind glass plates, others being water-tight metal units moulded in the pool wall, and still others being water-tight self-contained units operating completely surrounded by water but located generally in niches prepared for them in the pool wall.

International Commission on Illumination

The last year was a very important one for the U. S. National Committee, inasmuch as the American meeting of the International Commission on Illumination was held then.

The commission has some 15 technical committees, all of which met at Saranac Inn and considered the

recommendations and reports from various national committees, with a view to formulating recommendations for adoption by the commission. The technical papers at this meeting covered a wide variety of subjects, the practical details of lighting practise receiving a very large amount of attention.

The proceedings of the meeting which are now being printed will make a volume upward of 1500 pages, constituting a very notable summary of the existing state of the art and science of illumination not only in this country but throughout the world.

The next meeting of the commission, in 1931, is to be held in England.

The committee wishes to acknowledge the cooperation of the following men not members of the committee: E. W. Beggs, H. S. Broadbent, R. E. Carlson, R. W. Cost, C. Dick, S. G. Hibben, H. C. Rentschler, Geo. H. St. John, and R. L. Zahour of the Westinghouse Lamp Company; R. E. Farnham and James M. Ketch of the National Lamp Works of the General Electric Company; A. L. Broe, E. B. Fox, A. L. Powell and G. F. Prideaux of the Edison Lamp Works of the General Electric Company; C. A. B. Halvorson of the General Electric Company, West Lynn, Mass.; H. P. Gage, of the Corning Glass Works; Loyd A. Jones of the Eastman Kodak Company; K. W. Mackall of the Crouse-Hinds Company; R. D. Mailey of the Cooper Hewitt Electric Company; S. R. McCandless of the School of Fine Arts, Yale University; and C. H. Sharp of the Electrical Testing Laboratories.

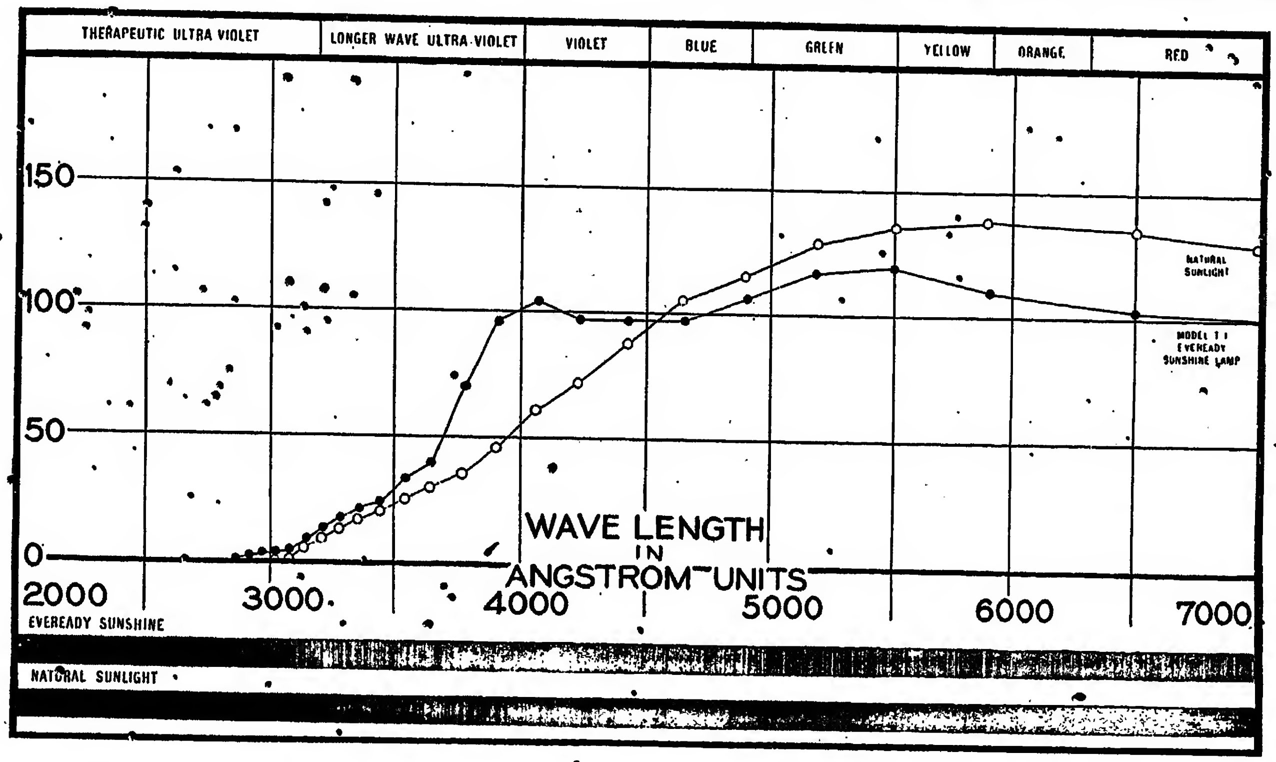
ILLUMINATION ITEMS

Submitted by the Committee on Production and Application of Light

THE ELECTRICAL ENGINEER AND LIGHT THERAPY

W. C. Kalb[1]

The popularity of the present sun-tan vogue and its hearty endorsement by prominent members of the medical profession point to the probability of the demand for artificial sources of sunshine being permanent rather than the fad of a day.



Due to this fact there has been a marked stimulation of research with the purpose of producing artificial sources of illumination closely approximating the radiations received from natural sunlight. Through the centuries, mankind has grown accustomed to sunshine. It is as essential to life and health as food, water, or air. Normal growth and development of the child demand complete sunshine.

The electrical engineer is not concerned primarily with the application of light in the therapeutic sense; the treatment and cure of disease is essentially the function of the physician, not of the engineer. However, electrical sources of illumination having been found to be the most practicable means of reproducing

1. National Carbon Company, Cleveland, O.

all the bands of radiation found in sunlight and even rays of shorter wavelength valuable in light therapy, the electrical engineer is vitally concerned with the growth of knowledge in this field to the end of providing still more efficient light producing units.

Through the demand for an artificial source of sunshine to be used in the home and a dependable source of ultra-violet radiation for use in light therapy, the carbon arc has received a new stimulus. Instantly available at full intensity and free from loss of efficiency with use, this type of illuminant is attracting marked attention.

Carbons used for light treatment are almost invariably of the flame type. The outer shell of pure carbon is filled with a core of flame-supporting material and the greater portion of the radiation comes from the flame of the arc rather than the incandescent tips of the carbons. By varying the composition of the core, the characteristics of the radiation emitted can be modified.

For the close reproduction of natural sunlight, cerium is used in the core of the carbon electrodes. The bare arc thus formed has a distribution of radiant energy c ose to that of natural sunlight. Like all carbon arcs, however, it emits some rays of wavelengths shorter than 2900 Angstrom units, the shortest rays reaching us in natural sunlight. These can be screened out by using a suitable filter of special ultra-violet transmitting glass. The efficiency of this arc for purposes of irradiation and the similarity to the radiant energy distribution of natural sunlight can be further increased by the use of a suitably designed reflector. The accompanying figure illustrates by means of curves and spectograms the distribution of radiant energy for natural sunlight in comparison with that of a cerium-cored carbon arc backed by a carefully designed chromium plated reflector and screened by a filter of special ultra-violet transmitting glass.

In the treatment of physical disorders the physician makes use of ultra-violet radiations shorter than those found in natural sunlight as well as infra red rays of greater proportional intensity than that normal to sunlight. The carbon arc may be adapted to these special requirements by selecting suitable materials for the composition of the core.

The use of iron in the core of the carbon electrodes gives strong ultra-violet radiation in the band from 2300 to 3200 Angstrom units. A polymetallic core composed of iron, nickel, aluminum, and silicon is particularly strong in the zone from 2700 to 3200 Angstrom units. This embraces that band of rays which medical authorities consider most effective in the cure and prevention of rickets as well as those rays having the most rapid action in producing pigmentation of the skin.

Cobalt in the core of the carbon gives considerable ultra-violet intensity from 3100 to 3500 Angstrom units, but its most striking effect is that the proportion of radiant energy in wavelengths less than 2500 Angstrom units to total radiant energy is greater than that for any of the other core materials here discussed.

To produce a carbon emitting a high percentage of infra red rays, strontium is used in the core. The light from the arc formed by this carbon is decidedly reddish in color, and the quantity as well as the percentage of infra red radiation greater than that obtained from any of the other core materials.

The foregoing statements clearly illustrate the versatility of the carbon arc. By modifying the composition of the core many other variations are possible. Experience, however, indicates that with the five types of carbon electrodes here described it is possible to obtain practically any distribution of radiant energy which the physician may desire in the practise of light therapy.

MOBILE COLOR LIGHTING AT BARCELONA EXPOSITION

C. J. Stahl[1]

From the standpoint of mobile color lighting, the International Exposition held this year at Barcelona, Spain, is the most exquisite display of its kind ever produced. It is particularly interesting as to the quantity of colored light employed and the extent of the area over which coordinated sequence is maintained, In length, this area is approximately one-third of a mile. and in width it averages 350 ft. Both as to colors and intensities, this widespread synchronized mobility is controlled through a multiplicity of circuits which appear hopelessly intricate until the systematic desing and arrangements are understood. The apparatus, to control automatically the changing colors, (5000-kw. connected load), cost approximately $250,000.00 exclusive of freight, erection, wiring, or the electric distribution system.

The sloping exposition area was transformed into a series of terraced gardens where luxuriant trees, beautiful flower beds, fountains, statuary, and cascades adorn the grounds.

Throughout this area, the colored lighting display is composed of the following elements:

1. There is an aurora of searchlight beams from 24 to 36 in.; 150-ampere searchlights placed back of the dome of the National Palace.

2. There are four cascades which are illuminated in mobile colors, so that the color seems to flow down like the water that carries it; only more slowly.

3. There are more than fifty fountains all fully illuminated and controlled so that color changes may be synchronized with the changing colors of the cascades.

4. There are approximately two hundred glass columns of various shapes and, in addition, many urns,

1. Manager, Illuminating Engineering Bureau, Westinghouse Elec. & Mfg. Co., South Bend, Ind.

flower pots, and fire pots, most of which can be synchronized in like manner.

From back of the dome of the National Palace overtowering the central area, an aurora of colored searchlight beams fan out over the heavens. As the aurora radiates upward, the ground display is a great stream of color consisting of the cascades, fountains, crystal columns and various other ornamental shapes, all aglow with colored light which progresses through consecutive dimming and brightening so that it seems to flow down the inclined central area. The effect is that of a mammoth staircase, almost half a mile in length, illuminated with slowly moving waves of color. Blue, for example, starts from the National Palace at the top and moves slowly down. When the blue has gone 200 meters, the effect of a mixture of red appears, gradually changing to pure red. Green follows, and then white, which holds until the advancing colors have reached the lower end of the Avenida de Americas, the time consumed being twelve minutes. By pressing a button at the central-control station, the entire cycle is repeated. At this station, one or more artists supervise the composition of the almost endless variety of color combinations, of which twenty may be set up in advance. Considering that the color panorama of the central area takes in four cascades, three large fountains and more than fifty small ones, as well as some two hundred or more glass ornaments, a most beautiful effect in mobile colors is produced. Adding to this the colored lighting of facades bounding the central area (which can be carried forward in steps to coordinate with the mobile progressions) also the changing aspects of the fountains due to great flexibility in hydraulic controls, we begin to picture a spectacle of supereminent beauty.

The floodlighting of facades, domes, and minarets is accomplished mostly by light directed upward. This creates shadows, and these, as well as small arches, niches, and other architectural indentures, are lighted from concealed sources in soft contrasting colors to accentuate the architectural embellishments both by depth and color contrasts. Yellow, red, and light green are used most for this purpose.

Where facades are illuminated in order to give the impression of interior life, the windows, doors and porticos are illuminated from the back, all in soft tones harmonizing with the lighting of the facades.

Stone incense pots showing colored vapors are also employed at certain locations. In general, green and light blue colors for static effects of considerable duration are preferred to deep reds; orange and gold, however, are not lacking. All elements are softly illuminated with diffused light, avoiding unpleasant glare. The qualities of comfort, mystery, elusiveness and colossalism are outstanding.

In general, reactors are employed for the dimming of lights. Many of these are of 200-kw. capacity. They are placed at remote points close to the load they control. Motor-generator sets are used in connection with the 200-kw. reactors, the control being effected by bringing the shunt-field circuit of the d-c. generator to the dimming resistance plate at the central control station.

As resistance is cut out in the dimming cycle, the d-c. voltage of the motor-generator set increases and the direct current delivered to the reactor by the motor-generator set therefore also increases. This decreases the effective resistance of the reactor, which is connected in series with the primary winding of the 5600-volt, 50-cycle transformers supplying energy to the lamp circuits. When the current in the d-c. winding of the reactor is at maximum, the secondary voltage of the supply transformers is at full normal voltage, and the lights at full brightness.

Space does not permit of a complete description of the Barcelona Exposition lighting here; a more detailed account was given at the Annual Convention of the Illuminating Engineering Society, September 1929.

THE MOTOR VEHICLE LIGHT TESTING LABORATORY OF MINNESOTA

PROF. W. T. RYAN

The regulations with respect to automobile headlamps, included in the Uniform Traffic Act of the State of Minnesota, have now been in force for over two years.

The Department of Electrical Engineering of the University of Minnesota established a testing laboratory which was designated by the Department of Highways, as the official testing laboratory for the State of Minnesota where the manufacturer's samples are checked to see that required specifications are met. Professor E. W. Johnson, Director of the Motor Vehicle Light Testing Laboratory, has served also as an adviser to the Department of Highways on questions relating to lamp specifications, testing, and approvals.

Samples from all of the principal manufacturing companies have been tested and the system is in active operation. A start has been made also in the enforcement of the headlamp adjustment requirements of this law, but much remains to be done in that line.

Improvement is apparent, however, in night driving conditions, although really only a beginning has as yet been made. One large contributing factor is the decided improvement in the quality of the headlamps coming in on the new cars. The worst offender among old ones, some of which could not be adjusted to give a good driving light and others exceedingly sensitive to focal adjustment, are gradually disappearing.

*Professor, Electrical Power Engineering University of Minnesota, Minneapolis, Minn.

INSTITUTE AND RELATED ACTIVITIES

The 1930 Winter Convention

LIVE TECHNICAL SUBJECTS AND ENJOYABLE ENTERTAINMENT ARE ON PROGRAM

One of the most interesting technical programs ever offered by the A. I. E. E. will be presented at the 1930 Winter Convention to be held in New York, January 27-31.

Other attractive features which will make this a most enjoyable convention are also being planned. These include inspection trips, a lecture, the Edison Medal presentation, a smoker, and a dinner dance.

The technical papers will cover the subjects of protective devices, power-system planning, field investigation of lightning, transoceanic telephony and telegraphy, dielectrics, welding, and electrical machinery.

A special program for the ladies—sightseeing tours, shopping trips, teas, card parties, etc.,—is being arranged by the Ladies Entertainment Committee.

Reduced railroad rates on the certificate plan will be in force; under this plan the round trip will cost only one and a half times the single fare. In order that this special rate may be obtained, everyone going to the Convention should secure a certificate from his local ticket agent. The return trip must have the same routing as used in attending the Convention and there are certain other restrictions which may be learned from local ticket agents.

As tentatively arranged the schedule of events is given below:

TENTATIVE PROGRAM OF WINTER CONVENTION

MONDAY, JANUARY 27

10:00 a. m.	Registration
2:00 p. m.	Session on Protective Devices
8:15 p. m.	Joint Session with Illuminating Engineering Society on Ultra Violet Radiation

TUESDAY, JANUARY 28

10:00 a. m.	Session on Power System Planning
2:00 p. m.	Session on Selected Subjects
8:00 p. m.	Smoker with Entertainment

WEDNESDAY, JANUARY 29

10:00 a. m.	Session on Lightning Investigations
2:00 p. m.	Inspection Trips
8:30 p. m.	Edison Medal Presentation and Lecture

THURSDAY, JANUARY 30

10:00 a. m.	Session on Transoceanic Communication
2:00 p. m.	Session on Welding
	Session on Dielectric
7:00 p. m.	Dinner Dance

FRIDAY, JANUARY 31

10:00 a. m.	Session on Electrical Machinery
2:00 p. m.	Session on Electrical Machinery

The technical papers deal with very live topics. The papers selected have been chosen from a very large number which were available. The following is a tentative selection of the papers to be presented.

SESSION ON PROTECTIVE DEVICES

January 27—2:00 p. m.

Metal-Clad Switchgear at State Line Station, A. M. Rossman, Sargent & Lundy, Inc.

Development of the New Autovalve Arrester, J. Slepian, R. Tanberg and C. E. Krause, Westinghouse Electric & Mfg. Co.

Thyrite, A New Material for Lightning Arresters, K. B. McEachron, General Electric Co.

Extinction of a Long A-c. Arc, J. Slepian, Westinghouse Electric & Mfg. Co.

Use of Oil in Arc Rupturing with Special Reference to System Stability, B. P. Baker and H. M. Wilcox, Westinghouse Electric & Mfg. Co.

JOINT SESSION, WITH ILLUMINATING ENGINEERING SOCIETY

January 27—8:15 p. m.

Production and Control of Ultra Violet Radiation, M. Luckiesh, National Lamp Works of General Electric Co.

An Ultra Violet Light Meter, H. C. Rentschler, Westinghouse Lamp Co.

SESSION ON POWER SYSTEM PLANNING

January 28—10:00 a. m.

System Connections and Interconnections in Chicago District, G. M. Armbrust and T. G. Le Clair, Commonwealth Edison Co.

Fundamental Plan of Power Supply in the Detroit District, S. M. Dean, Detroit Edison Co.

Fundamental Plan of Power Supply in the Philadelphia Area, Raymond Bailey, Philadelphia Electric Co.

Turbine-Governor Tests at Colfax Power Station, T. C. Purcell and A. P. Hayward, Duquesne Light Co.

Controlling Power Flow with Phase-Shifting Equipment, W. J. Lyman, Duquesne Light Co.

SESSION ON SELECTED SUBJECTS

January 28—2:00 p. m.

The Units of the Magnetic Circuit, A. E. Kennelly, Harvard University

The Calculation of Induced Voltages in Metallic Conductors, H. B. Dwight, Massachusetts Institute of Technology

Induced Voltage of Electrical Machines, L. V. Bewley, General Electric Co.

Design and Application of a Cathode Ray Oscillograph with Norinder Relay, O. Ackermann, Westinghouse Electric & Mfg. Co.

SESSION ON LIGHTNING INVESTIGATIONS

January 29—10:00 a. m.

Résumé of 1929 Lightning Investigations, Subcommittee on Lightning, of Committee on Power Transmission and Distribution

Cathode Ray Oscillograph Studies of Lightning on Transmission Lines, J. H. Cox and Edward Beck, Westinghouse Electric & Mfg. Co.

Surge Characteristics of Insulators and Gaps, J. J. Torok, Westinghouse Electric & Mfg. Co.

Lightning Voltages on Transmission Lines, R. H. George, Purdue University and J. R. Eaton, Consumers Power Company

Study of Traveling Waves on Transmission Lines with Artificial Lightning Surges, K. B. McEachron and W. J. Rudge, General Electric Co., and J. G. Hemstreet, Consumers Power Co.

Lightning Investigation on 220-Kv. System of Pennsylvania Power and Light Co., Nicholas N. Smeloff, Penn. Power & Light Co., and A. L. Price, General Electric Co.

Lightning Investigation on Ohio Power Co. System, F. W. Peek, General Electric Co, and Philip Sporn, American Gas & Elec. Co.

SESSION ON COMMUNICATION

January 30—10:00 a. m.

The Post-War Decade in Submarine Telegraphy, J. S. Coggeshall, Western Union Telegraph Co.

Transocean Telephone Service—General Aspects, J. J. Pilliod, American Telephone & Telegraph Co.

Short-Wave Radio Transocean Telephone Circuits

(a) *Transmission Features of Short-Wave Radio Circuits*, R. Brown, American Telephone & Telegraph Co.

(b) *Technical Features of the New Short-Wave Radio Station of the Bell System*, A. A. Oswald, Bell Telephone Laboratories, Inc.

(c) *Plan and Construction of Short-Wave Radio Systems*, F. A. Cowan, American Telephone & Telegraph Co.

SESSION ON WELDING

January 30—2:00 p. m.

Cathode Energy of the Iron Arc, G. E. Doan, Lehigh Univ.

Resistance Welding, B. T. Mottinger, Federal Machine & Welder Co.

Electrically Welded Structures under Dynamic Stress, Morris Stone and J. G. Ritter, Westinghouse Electric & Mfg. Co.

Welding with the Carbon Arc, J. C. Lincoln, Lincoln Electric Co.

SESSION ON DIELECTRICS

January 30—2:00 p. m.

Conductivity of Insulating Oils, J. B. Whitehead and R. H. Marvin, Johns Hopkins University

Behavior of Dielectrics, R. R. Benedict, University of Wisconsin

Three Regions of Dielectric Breakdown, P. H. Moon, and A. S. Norcross, Massachusetts Institute of Technology

Ionization Studies in Paper-Insulated Cables—III, C. L. Dawes and P. H. Humphries, Harvard Engineering School

High-Voltage Corona in Air, S. K. Waldorf, Johns Hopkins University

SESSION ON ELECTRICAL MACHINERY

January 31—10:00 a. m.

Loading Transformers by Temperature, V. M. Montsinger, General Electric Co.

Recommendations for Safe Loading of Transformers by Temperature, W. M. Dann, Westinghouse Electric & Mfg. Co.

Tap Changing Under Load for Voltages and Phase-Angle Control, H. B. West, Westinghouse Electric & Mfg. Co.

Telephone Interference from A-c. Generators Feeding Directly on Line with Neutral Grounded, J. J. Smith, General Electric Co.

Grounding Impedance, K. K. Palueff, General Electric Co.

SESSION ON ELECTRICAL MACHINERY

January 31—2.00 p. m.

Generalized Theory of Electrical Machinery, Gabriel Kron, Lincoln Electric Co.

Quiet Induction Motors, L. E. Hildebrand, General Electric Co.

Transient Torque—Angle Characteristics of Synchronous Machines, W. V. Lyon and H. E. Edgerton, Massachusetts Institute of Technology

Starting Performance of Salient-Pole Synchronous Machines, T. M. Linville, General Electric Co.

Ventilation of Revolving-Field Salient-Pole Alternators, C. J. Fechheimer, Westinghouse Electric & Mfg. Co.

Synchronous Machines, V, (Three-Phase Short Circuit), R. E. Doherty and C. A. Nickle, General Electric Co.

Committees

The 1930 Winter Convention Committee is as follows: H. P. Charlesworth, Chairman; J. B. Bassett, S. P. Grace, C. R. Jones, H. A. Kidder, G. L. Knight, E. B. Meyer, and C. E. Stephens.

The chairmen of the subcommittees are, respectively: *Entertainment*, J. B. Bassett; *Inspection Trips*, F. Zogbaum; *Dinner-Dance*, C. R. Jones; *Smoker*, G. J. Read, and *Ladies Entertainment*, Mrs. G. L. Knight.

District Meeting in Chicago

The three-day District Meeting at the Drake Hotel in Chicago December 2-4 has a splendid program for both members and students. Complete details of the meeting were announced in the November issue of the JOURNAL page 843. No extensive announcement is given in this issue as the meeting will be in progress before the issue reaches most of the membership.

World Engineering Congress, Tokyo

The American delegation to the Tokyo Congress arrived in Japan October 22 and 28 after an exceedingly interesting voyage across the Pacific on the steamers *President Jackson, Korea Maru* and *Empress of France*. Japanese reception committees welcomed the Americans and expedited their arrival at the various Hotels to which they were destined.

The Congress opened with an official reception at the Imperial Hotel Tokyo, on Monday evening October 28th.

The official opening of the Congress sessions occurred on the morning of October 29, the opening address being given by His Imperial Highness, Prince Chichibu, followed by addresses by the Prime Minister of Japan, Baron Furnichi, President of the Congress, and short addresses by representatives of the various National delegations.

The technical papers were presented in twelve separate sections covering various subjects. The total number of papers listed in the program comprised several hundred by authors from all parts of the world, making it necessary to hold ten sessions of the Congress simultaneously. The Tokyo Sectional Meeting of the World Power Conference was held in conjunction with the Congress, with a technical program so extensive that two sessions were conducted simultaneously each day.

The social events, excursions, etc., were so numerous that here mere mention only is possible. They included dinners, luncheons, teas, garden parties, and other hospitalities for which the Japanese are noted. Many events were arranged particularly for the ladies in attendance. Some of the functions of particular interest were a reception at the Prime Ministers official residence, a tea party and "Nō" dance at Baron Mitsui's residence, a garden party given by Prince and Princess Chichibu at the Imperial Gardens, a luncheon given by the Mayor of Tokyo, a garden party at the residence of Baron Iwasaki, and many others scheduled for the remaining days of the Congress.

The American Committee gave a dinner on October 31, at which the guests included Their Imperial Highnesses the Prince and Princess Chichibu and the delegates of all other countries represented at the Congress. The total attendance exceeded 700. Addresses were given by Chairman Sperry of the American Committee, Doctor F. B. Jewett and George Otis Smith.

At this writing, the Congress program is about half completed. After adjournment on November 7, the delegates and guests will participate in various excursions to places of engineering and scenic interest in Japan, Manchuria, China and elsewhere; a considerable number will continue their journey around the world.

Inquiries regarding the technical program and the availability of copies of the papers presented may be addressed to Mr. Maurice Holland, Secretary of the American Committee of the Congress, 29 West 39th St., New York.

Information relating to the technical papers presented at the World Power Conference may be obtained from Mr. O. C. Merrill, Chairman American National Committee, World Power Conference, 917 15th St., N. W., Washington, D. C.

ENGINEERING FOUNDATION

VISIT OF PROFESSOR ALBERT VAN HECKE OF LOUVAIN UNIVERSITY

As a fellow of the C R B Educational Foundation, Professor Albert Van Hecke, head of the Civil Engineering Department of Louvain University, is visiting Engineering Foundation and his other friends in the United States. He proposes to spend several weeks in study of recent advances in engineering research and practise in this country, his itinerary including Columbia University, University of Illinois, Massachusetts Institute of Technology, Princeton University and many others. By invitation he will participate in the celebration of the 175th anniversary of Columbia University; as the guest of Colonel Arthur S. Dwight, a former Trustee of the University, he will attend the alumni dinner.

On Dr. Van Hecke's arrival in New York October 21st he was taken to the Edison celebration at Menlo Park as the guest of Doctor Edward Dean Adams, Past-President of the Edison Pioneers and Honorary Member of Engineering Foundation. Doctor Adams was also Chairman of the Louvain Library War Memorial to American Engineers. On the evening of October 22nd Doctor Van Hecke was the guest of honor at a dinner given at the Century Association by Alfred D. Flinn, Director of Engineering Foundation and Secretary of the War Memorial Committee, for members of the Committee and delegates to the dedication of the Library.

Professor Van Hecke is assisting also in developing American interest in the Steel Construction Congress to be held in Liege, Belgium, the latter part of the summer of 1930. The American Society of Civil Engineers and the American Institute of Steel Construction will participate in the Congress through the attendance of delegates and the presentation of papers and addresses. This Congress is a part of the celebration of the 100th anniversary of Belgian independence.

American Committee World Power Conference

The American Committee of the World Power Conference will give a dinner in honor of Doctor O. von Miller, Honorary President of the Second World Power Conference, Saturday, December 7th, at the Metropolitan Club, New York City.

Doctor von Miller is in the United States to discuss plans with prominent engineers and business men for the participation of this country in the World Power Conference to be held in Berlin, June 16-25, 1930.

Mr. Henry J. Pierce, Vice-Chairman of the American Committee, is in charge of arrangements here for the entertainment of Doctor von Miller, who is a Director of the Allgemeine Elektrizitäts Gesellschaft, and the founder and organizer of the German Museum for natural and technical science in Munich.

Special Symposium at American Mathematical Society Meeting

Among the special features of the Thirty-Sixth Annual Meeting of the American Mathematical Society to be held at Lehigh University, Bethlehem, Pennsylvania, December 26-28, 1929, are two sessions devoted to an Engineering Symposium with some of the most distinguished research engineers participating. The general topic chosen is *Differential Equations of Engineering* and it is proposed that at each of the sessions on Saturday three half-hour papers be given by men eminent in their respective fields. The following is a list of the papers proposed:

The problem of diffusion, Professor H. W. March, University of Wisconsin.

Integraphs for differential equations, Professor Vannevar Bush, Massachusetts Institute of Technology.

Numerical integration of differential equations, Dr. T. H. Gronwall, Physics Department, Columbia University.

Plasticity and related problems of non-rigid bodies, Dr. A. Nadai, Westinghouse Electric and Manufacturing Company (formerly Professor of Applied Mechanics, University of Göttingen.

Analytic determination of flux plots, Mr. R. H. Park, Engineering Department, General Electric Company.

Problems in elasticity, Professor S. Timoshenko, University of Michigan (formerly with Westinghouse Electric and Manufacturing Company.

The meetings will be held in the new Packard Laboratory for electrical and mechanical engineering, a building which sets a new standard in equipment for teaching and research in engineering.

Following the Symposium on Mathematics in Engineering, on Saturday evening, December 28, there will be a conference on the general topic of the establishment of a Journal in Applied Mathematics.

New York Section Meetings of Illuminating Engineers

At the December 12th meeting to be held in one of the newer hotels in New York City, The Modern Trend in Home Lighting will be discussed. Special arrangements are being made to make it of particular interest to the ladies, with an exhibit of some most recently developed types of equipment.

The January 9, 1930 meeting will be on Inspection of Novel Color Cove Lighting Installation in Main Ball Room at the Hotel St. George, Brooklyn, N. Y. F. J. Cadenas will demonstrate and explain the installation and M. Messner of Bing and Bing Corporation will speak on decorating with colored lighting versus paint and fabric.

STANDARDS

Symbols for Photometry and Illumination

A revision of the Symbols for Photometry and Illumination has been drawn up by a subcommittee of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations working under the procedure of the American Standards Association. The present Section of the A. I. E. E. Standards No. 37, entitled "Illuminating Engineering Nomenclature and Photometric Standards" contains the list of symbols of which this report is a revision. No. 37 was prepared under the direction of the Illuminating Engineering Society and became an American Standard in 1925. The proposed revision was approved by the Board of Directors of the Institute, one of the sponsors at their meeting of October 18th. As soon as approval of the revision as an American Standard is obtained a revised edition of No. 37 will be issued.

Navigational and Topographical Symbols

A report on Navigational and Topographical Symbols has been submitted for approval by a subcommittee of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations. This report is identical with the symbols covered by the chart "Standard Symbols Adopted by the Board of Surveys and Maps, United States of America," edition of 1925 except as follows: That the symbols for Aerial Navigation be superseded by those adopted by that Board in 1928; and that the abbreviations for use on military maps be omitted. The report of the subcommittee included some recommendations of a minor nature, particularly with regard to miscellaneous information shown on map. The report was approved by the Institute as one of the joint sponsors by action of the Board of Directors on October 18th. For details of report inquiry should be made through the headquarters of the American Standards Association, (Dr. P. G. Agnew, Secretary), 33 West 39th St., New

York, N. Y. Copies of the chart of Standard Symbols may be obtained through the U. S. Geological Survey, Washington, D. C. Price 40 cents.

National Electrical Code Approved

The 1929 edition of the National Electrical Code has been approved as an American Standard by the American Standards Association. The technical provisions of the new edition are not materially changed although certain new practises have secured recognition. Copies of the code can be obtained through the National Fire Protection Association, 109 Leonard St., New York, N. Y.

Protection of Electrical Circuits and Equipment Against Lightning

For a number of years, through the medium of a Sectional Committee organized under the procedure of the American Standards Association, the A. I. E. E. and the Bureau of Standards have been engaged in developing "Standards for Protection of Electrical Circuits and Equipment Against Lightning." The preliminary report of the Sectional Committee has just been published by the Department of Commerce as Miscellaneous Publication No. 95 of the Bureau of Standards. The protection of persons, buildings, oil tanks, etc., has been dealt with in the "Code for Protection Against Lightning" which is already an approved American Standard. Originally, it was intended that in addition to the material in this Code there should be additional facts dealing with the protection of power and railway circuits and equipment. Present practise in these fields has not however crystallized to the point where it is felt that definite standards could be set up. Nevertheless, the committee collected information as to methods of protection now in vogue and practises which have been found satisfactory. This preliminary report has therefore been issued not only to make available the material therein, but of presenting the present results for consideration and criticism. Copies of the report may be purchased at a cost of 25 cents from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Faraday Electromagnetic Centenary

Arrangements initiated by the Royal Institution for the celebration of the Centenary of Faraday's discovery of electromagnetic induction have already been announced. At a representative meeting held at the House of the Institution on February 5th, 1929 the formation of two committees was agreed to, and these committees are now at work. The first, consisting of representatives of the Royal Society, the British Association, and other scientific societies, as well as the Royal Institution, is concerned with the purely scientific aspects of Faraday's work in relation to the proposed celebrations; the second committee, which has been called together by the Institution of Electrical Engineers consists of representatives of the principal organizations of those industries which have risen in the past hundred years upon the scientific foundation of Faraday's discoveries and is dealing with the industrial aspects of the celebrations.

The two committees are working in close cooperation; the preliminary discussions which have taken place indicate that the significance of the Centenary is very widely appreciated and that the celebrations are likely to arouse world-wide interest and support. The dates have now been fixed and the proceedings will commence in London on Monday, September 21st, 1931. Further, an intimation has been received from the British Association that their Centenary Meeting will be held in London during the week commencing September 23rd, 1931. These two Centenaries, with important electrical conferences and other events which are to take place about the same time, will thus conjoin to make the year 1931 a memorable one in this and every country where the genius of Faraday has borne fruit.

American Engineering Council

ANNUAL MEETING

It was decided that the annual meeting of American Engineering Council would be held in Washington, D. C., January 9-11, 1930.

A. E. C. MAPPING PROGRAM

Pursuant to the instructions of the Administrative Board of American Engineering Council, the Executive Secretary had conference with the Secretaries of Commerce and Interior and the Director of the Bureau of the Budget for the purpose of pointing out to them the need of an increased appropriation for the topographic and water resources work of the U. S. Geological Survey, and also for the Hydrographic Branch of the Coast and Geodetic Survey Branches. Those conferred with were keenly aware of the value of such work and the necessity of expediting it, and expressed a desire to do what they could to bring about an enlargement of the work.

Following an interview with Secretaries Wilbur and Lamont, President Hoover issued a statement saying that a program had been perfected by the Secretaries of Interior and Commerce under which topographic coast and geodetic surveys of the United States are to be completed within 18 years, instead of 20 years as originally planned. The program will be made effective in this year's budget. It is estimated that it will cost $1,000,000 more annually to expedite the surveys. This would seem to indicate that the present administration is cognizant of the need of expediting the topographic survey program and that the provisions of the Temple Act are being taken seriously.

RECOMMENDS ENGINEERS FOR INTERNATIONAL JOINT COMMISSION

As a matter of policy, the question of securing engineering representation upon the International Joint Commission came up for consideration. Council voted to authorize and instruct the Executive Secretary to do what in his judgment seemed best to accomplish the appointment of civilian engineers on this Commission.

TWO-HUNDREDTH ANNIVERSARY OF BIRTH OF FIRST ENGINEER PRESIDENT

A special committee composed of Lieutenant-Colonel U. S. Grant, 3rd; Colonel C. H. Birdseye; Dean A. N. Johnson; Colonel D. H. Sawyer; A. G. Bruce, and J. C. Hoyt, have carefully studied the various projects offered as a possible means of engineering participation in the celebration of the two hundredth anniversary of the birth of George Washington, the first engineer President of the United States. This committee brought in four proposals, two of which received the endorsement of Council. The first was the endorsement of the Cramton bill (H. R. 26) which provides for the acquisition, establishment, and development of the George Washington Memorial Parkway along the Potomac from Mt. Vernon and Fort Washington to the Great Falls, and the acquisition of lands in the District of Columbia, and Virginia requisite to the comprehensive park and playground system of the National Capital. This bill embodies a broad and constructive vision of a park system which will place Washington in a most favorable position in comparison with great European capitals.

The Administrative Board voted that Council recommend to the engineering profession as an appropriate participation in the celebration of the two hundredth anniversary of the birth of Washington, and as a tribute to and memorial of Washington, the Engineer, that the profession undertake to repair sufficiently to preserve the structures of the so-called "Pawtowmack Canal," which canal is about one mile long, embracing five locks constructed under the personal supervision of Washington for the purpose of passing around the Great Falls of the Potomac River. The only structures now in existence known to have been the work of the first engineer President of the United States.

ST. LAWRENCE WATERWAY

The question of the St. Lawrence Waterway arose through consideration of S. J. Res. 37 and H. R. 733, the former proposing to state the position of the United States as endorsing the development of the St. Lawrence for ocean-going vessels, and the latter providing for a definite deep waterway for ocean-going vessels from the Great Lakes to the Atlantic by way of the St. Lawrence River and Welland Canal. Council favored these two bills in principle, and recommended the appointment of civilian engineers as well as Army engineers on the commission recommended by the two measures.

CONSULTING ENGINEERS FOR GOVERNMENT SERVICE

H. R. 4195 proposes to authorize the employment of consulting engineers for the Air Corps, Chemical Warfare, and Ordnance Departments. The maximum salary payable is $50 per diem. Council endorsed the Public Affairs Committee's recommendation that the same action be taken in connection with this bill as with the bill of similar nature relating to employment of consulting engineers for reclamation work,—namely, that the bill be approved in principle but with the comment that the rates of compensation provided are not those at which competent consulting opinion is obtainable—and if secured by the Government at the rates provided in the bill, it will be at the personal sacrifice of those accepting them.

STUDY OF AIRPORTS CONSIDERED

The Committee on Research recommended that Council make a cooperative study with the Bureau of Aeronautics, Department of Commerce, on the subject of airports. This recommendation was given careful consideration by a special committee composed of O. H. Koch, H. E. Howe, George T. Seabury, R. C. Marshall, Jr., J. L. Harrington, which recommended "that a committee be appointed to confer with the Bureau of Aeronautics to work out a plan whereby the Bureau and American Engineering Council may coöperate in formulating a report for the general information and guidance of public bodies into the diversibility and importance of engineering problems in the design of airports." This recommendation was adopted by Council.

ADVISORS FOR ROSENWALD MUSEUM

Walter Kaempffert, Director of the Rosenwald Industrial Museum of Chicago, has requested Council's cooperation in the establishment of this museum. The Administrative Board approved the Executive Committee's recommendation that Council accept the invitation of the officers of the Rosenwald Museum, and designate one or two advisors for the Museum's board of directors.

RELIEF OF ENGINEERS FROM DUTY WITH COMBAT FORCES

Secretary of War James W. Good recently in a letter to Congress requested that the President be empowered to exempt officers of the Corps of Engineers, Medical Corps, Ordnance Department, and Chemical Warfare Service from the provisions of the section of our National Defense Act requiring periodic duty with troops of one or more of the combatant arms. Mr. Good's recommendation has been referred to the House Committee on Military Affairs and a bill has been introduced into the Senate (S. 1883) carrying the provision requested by the administration. Secretary Good pointed out that in view of the increasing responsibilities of the Corps in connection with flood control projects and river and harbor works, and because of the increasing need for unbroken administrative direction in particular projects, that it would serve the public interest to permit the assignment of engineer officers to public works for such periods as necessary to complete them. Ordinarily such details would not extend beyond the four-year period and very few officers would be affected. Furthermore the proposed legislation would be without cost to the Government. The advantage of securing continuity of ministration in the large civil projects entrusted by Congress to the Corps of Engineers would, in the opinion of the Secretary of War be a substantial one. This is exactly the contention which representatives of American Engineering Council have continually made to Congress in hearings on the question of the establishment of a Department of Public Works.

PLEA FOR FOREST CONSERVATION

A delegation of individuals representing organizations interested in forest conservation called on President Hoover October 30 and presented a plea for increased appropriations for forest conservation work The delegation was headed by George D. Pratt, President of the American Forestry Association. American Engineering Council was represented by L. W. Wallace, Executive Secretary

Mr. Pratt, speaking to President Hoover on behalf of the delegation said, "These laws cannot become effective unless the appropriations authorized are granted by the Bureau of the Budget, the laws to which I refer are; 1. The Clarke-McNary Act with authorized appropriations of $2,700,000; 2. The Woodruff-McNary Act, with authorized appropriations of $8,000,000; unappropriated balance $4,000,000. 3. The McSweeney-McNary Act, with authorized appropriations of $3,575,000."

PERSONAL MENTION

Robert J. Hanchett has recently organized the Southern Electric Works, Inc., 1167 East 63d Street, Los Angeles, California, of which he is President and Consulting Electrical Engineer.

E. P. Dillon has just been made Vice-President in Charge of Sales of the E. Y. Sayer Engineering Corporation, New York, N. Y. Previously Mr. Dillon was Manager of the Research Corporation.

M. A. Mulvany has resigned the position of Radio Engineer (civilian) with the Navy at Pearl Harbor, to become Chief Engineer and Director of Radio for the Advertising Publishing Co. Limited, of Honolulu, T. H.

Sylvan Harris, identified with radio engineering for nearly ten years, has joined the engineering staff of Fada Radio, and has been assigned by F. A. D. Andrea, President of that company, to special research work in the Fada Laboratories in Long Island City.

D. McFarlan Moore, Fellow of the Institute and Research Engineer of the General Electric Company on November 5th delivered an address on Gaseous Conduction to a very much interested audience at the Lehigh University Chapter of the Society of the Sigma Xi, of which is is a member.

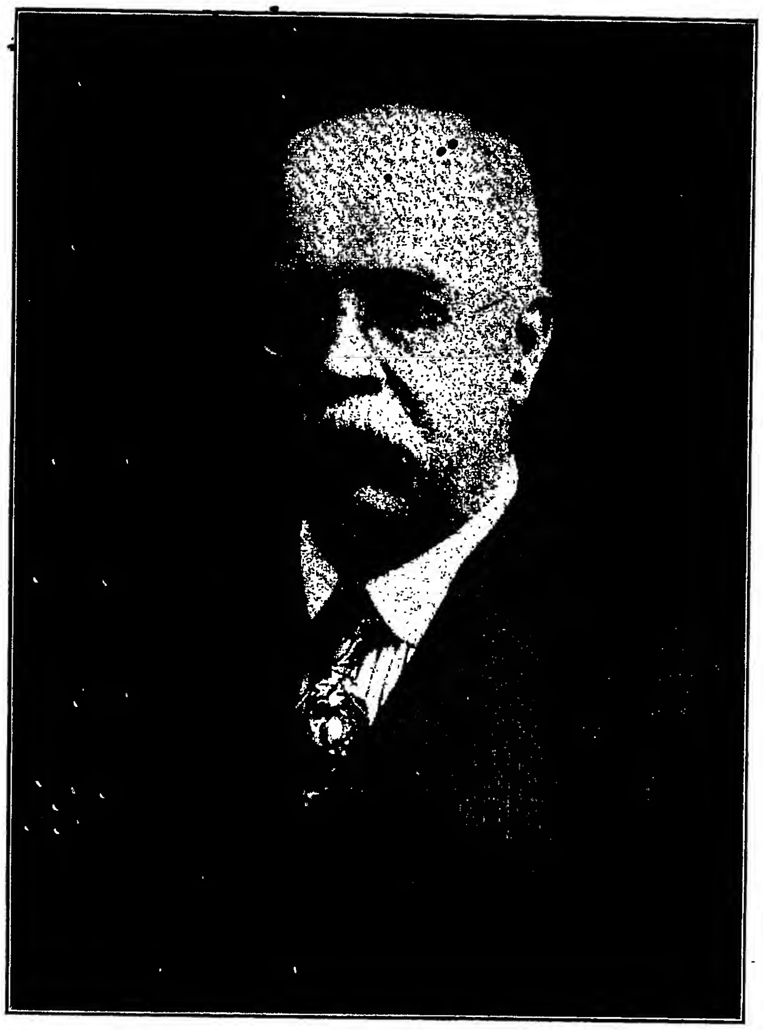
Edward B. Newill, of Forest Hills, has resigned as manager of the Control Engineering Department of the Westinghouse Electric and Manufacturing Company to become affiliated in an executive capacity with the radio manufacturing company being formed jointly by the General Motors Corporation and the Radio Corporation of America. Mr. Newill entered upon his new position October 16, under the title of assistant to the President of Delco Products Company, with temporary headquarters at Dayton, Ohio.

Death of Honorary Secretary Pope

RALPH WAINWRIGHT POPE, pioneer member of the Institute, elected its Secretary in 1885 and for twenty-seven years consecutively thereafter, died November 1, 1929 at his home in Great Barrington, Massachusetts. Although in his eighty-fifth year, he had apparently been in good health and the end came suddenly of heart failure.

Great Barrington, where he spent most of his life, was also his birthplace, his rudimentary schooling being acquired in the little old red schoolhouse there. In the autumn of 1857 he left the local school to attend the academy at Amherst, but ill health overtook him and he left the Amherst Academy to enter the North Amherst district school. He always learned quickly and was a pupil of good application, but because of sickness he dropped behind his classes and finally returned to Great Barrington, where he completed his school life at the age of thirteen.

The nature of his future undertakings was strongly evidenced in his childhood amusements; mechanism fascinated him and he created quite a monopoly on the small wheels from the carts of the children with whom he played, building with these spare parts, waterwheels, miniature railroads and various other experimental structures of mechanical nature. From one of his mother's plaster bonnet blocks he made a mold for more cartwheels, pouring into it melted lead and building up quite a local activity among his playmates.



RALPH WAINWRIGHT POPE

Upon his return to Great Barrington, he found his brother in charge of the local telegraph office. This offered a marvelous place in which to spend all his spare time, picking up a knowledge of telegraphy and unwittingly laying the foundation upon which his future career was built. Theodore M. Chapin, local station agent for the Housatonic Railroad, was without an assistant and took great interest in the boy, teaching him many phases of the railroad's activities and acquiring such faith in his ability to do that when the company was in need of a man, Ralph Pope was heartily recommended to Mr. Hunt, the assistant superintendent; at the age of fifteen he became telegrapher for the Housatonic Railroad Company. From that time he was continuously identified with electrical engineering work. The company sent him to the Bridgeport office, but he was returned to the Great Barrington office to meet an emergency situation arising in the service there.

The Hughes receiving instrument upon which Mr. Pope learned had now been changed to a Morse, but he easily accomplished the changeover in operation and was soon known as an "expert sound receiver." Consequently at the outbreak of the Civil War when dependable and competent operators were at a premium he was well qualified to offer his services and he was promptly installed in the New York office of the American Telegraph Company. The volume of work involved in the sending and receiving of war news was almost unlimited; close confinement was again telling upon Mr. Pope's health and much of night work with long hours was being pressed upon him. He was then twenty-two years of age and was on the verge of giving up; but the scarcity of operators impelled him to continue. He was, however, transferred shortly to the New Haven office and then to Providence at a good increase in salary.

In 1865 he joined the Collins overland telegraphic expedition, a famous pioneer band whose ambition it was to establish a through service to Europe by way of Alaska and Siberia. Mr. Pope went with them into the wilds of British Columbia in true pioneer fashion, sailing for San Francisco in April of that year and proceeding at once to Victoria, B. C. Final preparation for the pioneer life was completed at New Westminster. The party traveled up the Frazer River, sleeping in the open much of the time with nothing but their blankets for shelter, traveling sometimes on foot, sometimes on mules, pulling their boats after them on land that they might have them for the necessary fording of the stream in other sections. There is no truer test of adaptability than that imposed by such an adventure and through the entire experience this key-note of all Mr. Pope's life was characteristically demonstrated. Further effort of this expedition was finally abandoned with the successful laying of a transatlantic cable replacing the necessity which they were striving to meet.

For ten years subsequent Mr. Pope was in the service of the Gold and Stock Telegraph Company, resigning a position as its deputy superintendent in 1883 and until 1888 becoming actively interested in the editing and publication of technical electrical journals. He was associate editor of *The Telegrapher* and *The Electrical Engineer*, and editor of *Electric Power*, which he founded.

Under the energy and tact of his part time secretarial administration the Institute made rapid and important strides in its development and in 1887 he was persuaded to devote practically all of his time to its activities and interests. Constantly studying the needs of its progression and ever watchful of opportunity to recommend or endorse the adoption of methods to improve its work of cooperation in any advancement of the profession and general good of humanity, he labored unceasingly and diligently. The office of Secretary was an elective one and perhaps the greatest tribute paid to the worthiness and steadfastness of Mr. Pope's character lies in his repeated reelection by a membership vote. His clear conception of detail, painstaking, orderly methods and, withal, a genial and sympathetic spirit, endeared him to all and earned for him the gratitude and affectionate appreciation not only of the directors and members of the Institute but that of the multitude of other friends and fellow workers with whom his full and active life brought him in contact. He relinquished his active work as Secretary of the Institute in 1911, and was their appointed Honorary Secretary for life.

It was at his suggestion that the Institute's Sections were developed. Past-President Professor Charles F. Scott describes this epoch-making period of the Institute's history in brief as follows:

"In the spring of 1902 while the vote for President of the Institute was being canvassed, Secretary Pope said to me, 'Mr. Scott, it seems pretty certain that you will be the next President and I want to suggest that this will be an opportune time to develop local meetings of the Institute. There are now such meetings in Chicago, and they were held for a time by the St. Paul-Minneapolis group. This is an enterprise which I have been considering for a long time but have not received active support. It seems to me that you might take up the extension of local meetings during your administration.' I replied that I would vigorously support his proposal, as it was a practical means of expanding institute activities geographically; it would extend to distant members the new interest and impetus which Doctor Steinmetz (then President) was giving to the monthly meetings in New York. The appointment of a committee on local organizations was made at the first meeting in the fall and at my suggestion this committee was authorized to establish Student Branches as well as Sections among the Institute members. While President and committees gave support to the project, it was the enthusiasm and indefatigable interest of Secretary Pope that was one of the strong contributing factors in the development of the Sections and Branches which have so amply justified the vision and efforts of the faithful Secretary who served the Institute during its first quarter of a century."

Obituary

John William Lieb, senior Vice-President of the New York Edison Company and an outstanding worker in the electric public utility field, died at his home in New Rochelle, New York, November 1, 1929, after an illness of several weeks.

Mr. Lieb was the Institute's President 1904-1905. Throughout his life he played an important part in organization and execution in electrical and allied fields. He was born in Newark, New Jersey in 1860 and in 1880, was graduated from Stevens Institute of Technology. Almost immediately he took a position as draftsman with the Brush Electric Company in Cleveland, but after a few months of service, he joined the Edison Electric Light Company of New York, becoming assistant in the Engineering Department. He showed high executive ability, and evidently impressed Mr. Edison at once, for he was soon doing important work in planning the pioneer task that lay ahead of the company in supplying the city with incandescent lighting and other forms of electric power. Following the erection of the Pearl Street Station, he worked with Mr. Edison in the subsequent tests of its use and the inauguration of its service. On September 4, 1882, he was appointed first electrician of the company. So thorough and representative was Mr. Lieb's work that in 1883 Mr. Edison selected him as the man to go to Milan, Italy, to supervise the erection and operation of the station for the Italian Edison Company, as Director of the Societa Generale Italiana di Elettricita Sistema Edison, and for his work in introducing the use of electricity into Italy, he was made Knight Commander of the Royal Order of the Crown of Italy, in which he was later promoted to a Grand Officer. He was also made an officer of the French Legion of Honor.

At the invitation of the President of the Edison Electric Illuminating Company, Mr. Lieb in 1894 returned to New York as Assistant to the Vice-President. He was then made Vice-President and General Manager of the Company, and when the New York Edison Company was organized, he became Associate General Manager with the late Thomas E. Murray, eventually to occupy the office of Vice-President and General Manager. Last year, when the Brooklyn Edison was brought under the control of the Consolidated Gas Company—owner of the New York Edison and associated electric companies in the metropolitan district—with Mr. M. S. Sloan as President of the combined electric properties, Mr. Lieb retired from the more active duties of management to become Senior Vice-President.

John William Lieb

The Edison Medal was awarded him in 1923 "for the development and operation of electric central stations for illumination and power." He was a pioneer in the field of technical education, writing and lecturing extensively himself and owning perhaps one of the most comprehensive private libraries in existence. He is accredited with having the largest collection dealing with the work of Leonardo da Vinci ever made and for many years he was engaged in investigating and translating text of da Vinci research in natural science and engineering. (Through his membership in the Raccolta), of which he was a correspondent, many of these translations were transmitted to Italy and republished.

During the war period, Mr. Lieb as Chairman of the National Committee on Gas and Electric Service rendered valuable national service. He was also President and Chairman of the Board of the Electrical Testing Laboratories, Vice-President of the Electric Light and Power Installation Corporation; former President of the Edison Pioneers, the New York Electrical Society, and the National Electric Light Association. Besides his office as such in the New York Edison Company, he held directorship in the Yonkers Electric Light and Power Company, the United Electric Light and Power Company, the New York and Queens Electric Light and Power Company, the International

Power Securities Company, the Brush Electric Illuminating Company and the Empire City Subway Company. He was a Past-President of the American Society of Mechanical Engineers, a Fellow of the American Academy of Sciences, trustee of the Stevens Institute of Technology; trustee and Vice-President of the The Museums of the Peaceful Arts; trustee of the United Engineering Society and the Italy-America Society; and a member of the American Society of Civil Engineers, the Illuminating Engineering Society, Franklin Institute of Philadelphia, American Association for the Advancement of Science, and numerous other professional and civic organizations, national and local. He was an honorary member of the Society of Italian Engineers and Architects, and of the Society of Italian Railway Engineers; Vice-President of the Union Internationale des Producteurs et Distributeurs d'Energie Electrique; and a member of the Elektrotechnischer Verein, the Associazione Elettrotecnica Italiana, the Institution of Electrical Engineers of Great Britain, the Royal Society of Arts, and the Newcomen Society of London. In 1921 Stevens Institute conferred upon him the honorary degree of Doctor of Engineering.

Mr. Lieb's strong personality and vigorous leadership will be greatly missed in the many activities in which he was collaborative.

Guido Semenza, one of the best internationally known electrical engineers and Honorary Secretary for the Institute in Italy, died November 7, at Milan, after a protracted illness. His passing will be mourned by a host of friends to whom he had endeared himself by his intellectual ability, lovable character and charming personality.

He was born December 19, 1868 in London of Italian parentage. As a child he returned to Italy with his parents where his early education and classical studies began, and in 1893 he was graduated an Industrial Engineer (Electrical Section) from the Royal Polytechnic of Milan. Subsequently he received another degree in electrical engineering at the Institute Montefiore in Liege. The following year he became associated with the Milan Edison Company, later becoming its technical director.

In 1895-1896 he directed the construction of one of the pioneer hydroelectric developments, the Paderno Plant on the Adda, transmitting power to the City of Milan, and in that connection as a result of his keen analysis of the economics of transmission, he developed the "A" type of towers.

While engaged in central station work he made many contributions to the development of the art of power transmission and distribution. His progressive ideas and sound judgment attracted the attention of engineers and utility executives not only in Italy but in other countries, and the call for engineering advice on many new important projects led Mr. Semenza to leave the employment of the Milan Edison Company and open a consulting engineering office. Since then, Mr. Semenza was retained in a consulting capacity by innumerable private and public undertakings in all branches of electrical applications, including power generation, telephony, traction, etc. Some of his work was in foreign countries, making business connections with important engineering firms abroad, such as Merz & McLellan. During this time he also served as a member of the Board of Directors of many electrical companies.

In 1923 he succeeded in enlisting the necessary support to reorganize the company known as the C. G. S. (formerly Olivetti). He became its president, and in a very few years it reached a high degree of prosperity, becoming the largest manufacturer of electrical meters and instruments in Italy.

Outside of these professional pursuits, Mr. Semenza was a most devoted worker in all activities affecting the intellectual and industrial development of electrical associations in Italy and throughout the world. The transactions of engineering associations and congresses as well as technical periodicals are replete with his articles, discussions, and contributions, characterized by profundity of thought and clearness of expression.

He was President of the Associazione Elettrotecnica Italiana, to which he gave unsparingly of his time and ability, and a member of numerous foreign societies.

He was also one of the founders of the International Electrotechnical Commission, to which, since its inception, he had given generously of his time and advice. From 1923-1927 he served as its President and as such he presided at the convention in New York two years ago.

To Mr. Semenza for his persistent work and unexcelled, tactful handling of the many questions arising before that organization, the I. E. C. owes a great debt of gratitude.

Mr. Semenza was the type of a great engineer endowed with the most propitious aptitude for scientific studies and industrial activities, to both of which he contributed abundantly on the one hand, by evolving keen synthetic analysis of arduous scientific questions and on the other by directing and promoting industries. He aimed constantly at results without consideration of material interests.

Both from Italy and foreign governments and associations, Mr. Semenza received innumerable decorations and testimonials of recognition and esteem, but perhaps the most cherished to him must have been the award last spring of the Faraday Medal by the British Institution of Electrical Engineers. The recipients of the medal in the order of award are: Oliver Heaviside, Sir Charles Parsons, Dr. S. Z. de Ferranti, Sir J. J. Thomson, Colonel R. E. B. Crompton, Dr. Elihu Thomson, Professor J. A. Fleming, Guido Semenza. The year previous he was made an officer of the French Legion of Honor.

Henry A. Coles, District Manager of the Westinghouse Electric and Manufacturing Company's branch at Atlanta, Georgia, died October 27 at the Roosevelt Hotel, New Orleans. He was 63 years old and moved to Atlanta 30 years ago from Niagara Falls, where he was Sales Engineer for the Westinghouse Company.

Mr. Coles was born at Tallwood, Va., and attended Roanoke College. He was graduated from the University of Virginia in 1891. For a year he was associated with the Edison General Electric Company in Schenectady, resigning in 1892 to join the Westinghouse Company. Mr. Coles joined the Institute as an Associate in 1904 and advanced to Member in 1913.

Francis A. J. FitzGerald, Consulting Electrical Engineer of the FitzGerald Laboratories Inc., Niagara Falls, N. Y. and former President of the Electrochemical Society, died of pneumonia October 26 at his home in Niagara Falls, N. Y. He was born in Dublin, Ireland, June 1, 1870, his first education being in a private school; later in attending public school at Uppingham, England. In 1892 he obtained a degree of B. A., moderatorship and medal in Experimental Physics and Chemistry at Trinity College, Dublin University, Dublin, Ireland. He then came to this country and earned his B. S. in Electrical Engineering at the Massachusetts Institute of Technology. In 1895 he engaged with the Carborundum Company of Niagara Falls in charge of the Electric Furnace and Chemical Departments and in Research Work; in 1903 the FitzGerald and Bennie Laboratories were organized with Mr. FitzGerald Consulting Engineer. This work included design, construction and operation of the induction furnace plant of the American Electric Furnace Company as well as many other important plants for the Cartner Electrolytic Alkali Company, the National Carbon Company and others. Mr. Fitzgerald assisted in organizing the Acheson Graphite Company and in perfecting the graphite process; also aiding Doctor Acheson in other discoveries relating to graphite. He was a charter member of the Niagara Club. He became a Member of the Institute in 1914.

Walter H. Millan, Superintendent of Substations of the Union Electric Light and Power Co., died at his home at St. Louis, Mo. on November 13, 1929, at the age of 40. Mr. Millan was born at St. Louis, Mo. and was educated in the public and night schools of that city. In addition, he studied Electrical Engineering through the I. C. S. He began his service with the Union Electric Light and Power Co. in 1903 and has been a pioneer in the

development and application of automatic switching equipment for Edison systems and a-c. substations. Mr. Millan was elected an Associate of the Institute in 1914, a Member in 1921 and a Fellow in 1927. His interest in the Institute has been active and continuous. He served as Chairman of its Automatic Stations Committee in 1927 and 1928 and was a member of this committee in 1929. He served as Chairman of the St. Louis Section in 1927. In contribution to technical literature, in addition to various articles in the *Electrical World*, he has presented several papers before the Institute.

At the time of his death Mr. Millan was a member of the Engineers' Club of St. Louis; he was a Past Master of Pilgrim Lodge A. F. & A. M. No. 652 of St. Louis and a 14th degree Scottish Rite Mason.

Robert Meredith Searle, an Associate of the Institute since 1909 and President of the Rochester Gas & Electric Company, Rochester, N. Y., died at his home in that city November 13.

Mr. Searle was born at Peekskill, New York, March 3, 1869, he was educated, however, in the New York City schools. Ever since 1885 he had been in the gas and electric business, serving in almost every capacity from stationary engineer to president. Practical work in the engineering profession, with studying night and day, gave him high capability. His first work was as an office boy for Thomas A. Edison. Then he went to Philadelphia with the United Gas Improvement Company where his advancement was so rapid that before leaving to become foreman for the Consolidated Gas Company Plant in New York City, he had had charge of a number of plants as superintendent and engineer. Later he returned to the United Gas Company as Superintendent of its various plants and still later became operating executive of the Westchester Lighting Company at Mount Vernon, New York. In 1906 he was appointed General Manager of the Rochester Railway and Light Company, at that time controlled by the Andrews-Vanderbilt interests. The Rochester Gas and Electric Corporation grew out of this company, and Mr. Searle was advanced to the vice-presidency and ultimately to the presidency of the new company; in this office he remained the unanimous choice of holding concerns which subsequently controlled it. He also took a leading part in civic affairs and was at one time President of the Rochester Chamber of Commerce. In 1922 he became a member of an advisory committee to assist the Public Service Commission in aiding State public utilities to obtain coal during a strike period, and later became Fuel Administrator for the Western District of New York. For the past eight years he has worked on the problem of electrification of the New York Central's lines from New York to Buffalo, his ability in finance qualifying him to represent the railroad in this connection as well as from the electric power point of view. At the time of his death he was President and Director of the Rochester Gas and Electric Corporation, the Mount Morris Illuminating Company, the Mount Morris Water Power Company, the Geneseo Gas Light Company, the Caneadea Power Corporation, the Hilton Electric Light, Power and Heat Company and the Cooper Electric Corporation. He was also a Director of the Rochester Security Trust Company.

Arthur C. Scott, Consulting Engineer of Dallas, Texas, and a Member of the Institute since 1917, died in that city, at the age of 56. He was a native of Belmont, N. Y., received his degree of B. S. from R. I. College of A. & M. Arts in 1895, Mechanical Course; attended the summer courses at Harvard, Cornell, Massachusetts of Technology and the University of Wisconsin, in Physics, Geology and Electricity. From the University of Wisconsin in 1902 he received his Ph. D. degree in Electrical Engineering, Physics, and Geology. After his graduation from R. I. College in 1895 he had charge of the Departments of Physics and Electrical Engineering and from 1897, of the college lighting plant. His work in the development of the Department of Electrical Engineering at the University of Rhode Island was representative and most efficient; he also spent some time at the University of Ohio. He developed a number of principles bearing upon the operation of single-phase a-c. motors after he was professor in charge at the University of Texas, and in each instance he did excellent work. Professor Scott was a member of the Institute's Dallas Section.

A. I. E. E. National and District Prizes

The following National and District Prizes may be awarded each year:

National Prizes

1—First Prizes
- *Engineering Practise*
- *Theory and Research*
- *Public Relations and Education*

2—Prize for Initial Paper

3—Prize for Branch Paper

1—The National First Prize in each of the three classes; namely, *Engineering Practise, Theory and Research* and *Public Relations and Education*, consisting of $100.00 and a certificate, may be awarded to the author or authors of the best original paper presented at any National, District, or Section Meeting of the Institute.

2—The National Prize for Initial Paper, consisting of a certificate and $100.00 in cash, may be awarded to the author or authors of the most worthy paper presented at any National, District, or Section meeting of the Institute provided the author or authors have never previously presented a paper which has been accepted by the Meetings and Papers Committee.

3—The National Prize for Branch Paper consisting of a certificate and $100.00 in cash, may be awarded to the author or authors of the best paper based upon undergraduate work presented at a Branch or other Student meeting of the Institute, provided the author or authors are members of a Student Branch.

District Prizes

The following District Prizes may be awarded each year in each Geographical District of the Institute.

1—First Prize

2—Prize for Initial Paper

3—Prize for Branch Paper

Each District Prize shall consist of a certificate of award issued by the officers of the Geographical District, and $25.00 in cash. It may be awarded only to an author or authors who are located within the District, and for a paper presented at a meeting held within or under the auspices of the District.

1—The District First Prize may be awarded for the best paper presented at a National, District or Section meeting.

2—The District Prize for Initial Paper may be awarded for the best paper presented at a National, District or Section meeting, the author or authors of which have never before presented a paper before a National, District or Section Meeting of the Institute.

3—The District Prize for Branch Paper may be awarded for the best paper based on undergraduate work presented at a Branch or other Student Meeting of the Institute, the author or authors of which are members of a Student Branch.

The conditions of award of the various National and District Institute Prizes have been printed in pamphlet form, and during the month of October, a copy of this pamphlet was mailed to all District and Section officers and to the Counselors of all Student Branches.

Attention is directed to the fact that the conditions require that all papers presented during the calendar year 1929 and to be offered in competition for the National Prizes, must be received in triplicate at National Headquarters in New York on or before February 15, 1930. These papers may be submitted by the author or authors, by an officer of the Institute, or by the executive committees of Sections or Geographical Districts.

Papers to be considered in competition for District Prizes

should be submitted in duplicate by the authors or by the officers of the Branch, Section, or District concerned, to the District Committee on Awards, on or before January 10, 1930.

Any author or other member who is interested may obtain full information from the local Section or Branch officers, or by addressing Institute Headquarters, at New York.

A. I. E. E. Section Activities

POWER GROUP OF NEW YORK SECTION MEETS DECEMBER 9

The second meeting of the Power Group of the New York Section for this year will be held Monday evening, December 9, 1929 to 7:30 p. m. on the fifth floor of the Engineering Societies Building, 33 West 39th St., New York, N. Y.

The subject "System Connections" will include generally the various methods used for connecting systems with particular reference to the operation of the "synchronized-at-the-load" system in New York City. There will be three speakers; A. E. Powers, Westinghouse Elec. & Mfg. Co. will describe the general conception of stability both static and transient; I. H. Somers of the General Electric will present a paper dealing with the ring bus, the synchronizing bus, double windings, and the newer scheme, "synchronized-at-the-load." The third speaker, T. Maxwell, of the United Elec. Lt. & Pr. Co. will give a résumé of operating experience with the "synchronized-at-the-load" connections. There will be ample time for open discussion. To permit commuters to get an early train home, the meeting will adjourn at 9:30 oclock.

NEW YORK SECTION TO GET STATISTICS ON "HOW MUCH LIGHT"

For a number of weeks an informal committee organized at the instance of the New York Section of the A. I. E. E. has been at work assembling statistics of artificial lighting in the United States with the idea of preparing an estimate of the country's "saturation" in artificial light similar to the well-known estimates of saturation for household electric appliances, etc. Not only have the statistics of the industry and of the country been collected and studied but a painstaking effort is being made to establish, on purely physiologic grounds, the lighting levels which constitute the minimum for satisfactory eye work and the optimum for average eyes under ordinary working conditions. A summary of this data, expected to be of great interest in outlining expansions and other future plans for the lighting industry, will be presented at the meeting of the New York Section of the A. I. E. E. to be held at the Westinghouse Lighting Institute, Grand Central Palace, 480 Lexington Avenue, New York City, at 8:00 p. m. on Wednesday evening, December 18, 1929.

The speakers who will present this subject are: Arthur E. Allen, Vice-President of the Westinghouse Lamp Company and E. E. Free, Consulting Engineer. Two other speakers of prominence may be added.

After the meeting, guides will be provided and opportunity will be given for members to inspect the exhibits of the Westinghouse Lighting Institute.

As the auditorium at the Lighting Institute seats but 450, admission to the meeting will be placed on a ticket basis, each member being entitled to one ticket only. Full details will be given in the notice to be mailed to the Section membership during the first week of December.

FUTURE SECTION MEETINGS

Akron

December 13, 1929. *Railway Electrification*, by J. V. B. Duer, Electrical Engineer, Pennsylvania Railroad Company.

January 10, 1930. *The Problem of Public Transportation in Akron*, by L. G. Tighe, Assistant General Manager, Northern Ohio Power and Light Company.

Boston

December 10, 1929. *The Technique of Color and Talking Motion Pictures*, by H. L. Danson of the R. C. A. Photophone Corp. and Dr. L. T. Troland of the Technicolor Motion Picture Corp. Buffet supper at 6:30 in North Hall, M. I. T.

Cleveland

December 12, 1929. *Anti-Aircraft Artillery*, by Major G. M. Barnes, Ordnance Department, United States Army.

January 16, 1930. *Electricity and the Universe*, by David Dietz, Scientist and Author.

Detroit-Ann Arbor

December 10, 1929. *Power House Design*, by Alex Dow, President The Detroit Edison Company. Inspection trip through the New Delray Power House in the afternoon. Joint meeting with the Detroit Engineering Society at the Detroit Edison Auditorium.

January 21, 1930. Ladies' Night. *Motoring through Europe*, by Professor A. H. Lovell, Electrical Engineering Dept., University of Michigan, Ann Arbor, Michigan.

Lynn

December 4, 1929. Technical Lecture by H. D. Brown (*Mercury Arc Rectifiers*).

December 18, 1929. Popular Lecture.

January 29, 1930. *The Mysteries of Science*, by Harry C. White.

Pittsburgh

December 10, 1929. *Latest Developments in Supervisory Control*, by R. J. Wensley, Westinghouse Elec. & Mfg. Co., Mansfield, Ohio.

January 10, 1930. Dinner meeting. Professor Harold B. Smith, President, A. I. E. E., "The Quest of the Unknown". English Room, Fort Pitt Hotel.

NEW YORK SECTION POWER, TRANSPORTATION AND COMMUNICATION GROUPS MEET

On the evening of Wednesday, October 30, 1929, the Power Group opened the meeting year of the New York Section with a session held in the Engineering Societies Building, 33 West 39th Street, New York. George Sutherland, Chairman of the group and Assistant General Superintendent of the New York and Power Company, presided. About 250 members and guests attended.

The general subject of the meeting was: "Generation and the Development of Generators." Two speakers covered the topic as follows: H. C. Forbes, of the New York Edison Company, delivered a paper dealing with the high lights of generator development in the last few years, including the double-winding generator, hydrogen cooling, and the probable future trend in generation and generators as viewed from the standpoint of the operating engineer. The other speaker was C. M. Gilt of the Brooklyn Edison Company. He described the economic aspects of the situation, particularly the advantages of large units and the probable trend in generation and construction,—a discussion participated in by a number of members followed.

On Monday night, November 4, 1929, the Transportation Group held its first meeting. There was an attendance of about 100. The meeting was opened by C. R. Jones of the Westinghouse Electric & Mfg. Company, who called for the report of the Nominating Committee. This was read, and a group of officers

elected which included C. R. Jones, Chairman, and Alfred G. Oehler, Editor of the *Railway Electrical Engineer* as Vice-Chairman. The first speaker, Guy C. Hecker, General Secretary of the American Electric Railway Association, gave a general outline of the developments in the electric railway field and the conditions existing in those fields. The second speaker was A. O. Austin, Control Engineer, Westinghouse Electric & Mfg. Company, who described the technical features of modern control apparatus and the attempt being made to develop street cars with greatly increased acceleration possibilities and more powerful motor equipments to meet modern traffic conditions. A discussion participated in by a number of members followed. The meeting closed with the showing of a very interesting two-reel talking motion picture on traffic conditions in general and in various cities. This picture was obtained through the courtesy of the R. C. A. Photophone and the American Electric Railway Association.

The Communication Group held its first meeting of the year on Wednesday night, November 13, 1929 in the Engineering Societies Building. R. H. Hughes, Chairman of the Group, Assistant Vice-President of the New York Telephone Company presided. The general subject of the meeting was, "Materials of Communication." Four speakers covered the subject, as follows: W. W. Brown of the General Electric Co., gave a talk on "Micalex." The second talk on "Copper Oxide" by I. R. Smith of the Westinghouse Elec. & Mfg. Co. dealt with the use and performance of that type of rectifier. "Developments in Communication Materials" was the subject of a talk dealing with insulating materials and metals, including duralumin, permalloy, brasses and bronzes given by W. Fondiller of the Bell Telephone Laboratories. In a talk entitled "Manufacturing Problems in Communication Materials" the last speaker of the evening, D. Levinger of the Western Electric Co., described the problems which have been developed through introducing some of the newer materials into the manufacture of communication apparatus. Lantern slides and movies illustrated the talks. Open discussion followed. Over 250 were in attendance.

NEW YORK SECTION MEETING ON "WONDERS OF SOUND TRANSMISSION" PROVES VERY POPULAR

On Friday, November 8, 1929, the New York Section of the Institute held its first general meeting of the year. Before an audience of about 1400, Sergius P. Grace, Assistant Vice-President of the Bell Telephone Laboratories, Inc., delivered a lecture-demonstration on the "Wonders of Sound Transmission." This meeting was one of the most popular ever held in the Engineering Auditorium as in addition to those who heard Mr. Grace, at least 500 were turned away. Chairman H. P. Charlesworth opened the meeting promptly at 8:00 p. m. and after a few brief announcements, turned it over to Vice-President H. A. Kidder of the New York District, who introduced the speaker. Then in an exceedingly entertaining manner Mr. Grace, as proof of the great practical value of scientific research, outlined some of the developments made in the Bell Telephone Laboratories. Among the modern marvels explained and demonstrated were the electric ear, scrambled speech, delayed speech, amplified muscle noises, the artificial larynx, and translation of mechanical impulses into speech. At the close of the meeting which was adjourned at 9:50 p. m., a very large number of the audience crowded to the stage to examine the exhibits and demonstration apparatus, and to question Mr. Grace.

FIRST POWER GROUP MEETING—CHICAGO SECTION

On Thursday October 17, the first Power Group meeting of the Chicago Section of the A. I. E. E. was held in the club rooms of the Western Society of Engineers.

Mr. R. C. Bergvall, General Engineer, Westinghouse Electric & Mfg. Company presented a paper on *Present Tendencies in Power Transmission*, special attention being given to the matter of system stability.

The meeting was attended by over 100 engineers who participated actively in the discussion. This is the first of a series of group meetings especially arranged to appeal to younger engineers; and the Chicago Section plans to start other similar groups on other subjects, such as communication and transportation, as soon as they can be organized and gotten under way.

PAST SECTION MEETINGS

Akron

Inspection trip to Ohio Box Board Company, preceded by dinner at United Brethren Church. Mr. Breakwood of that company gave a talk on the manufacture of their product. General discussion followed. October 17. Attendance 80.

Heavy Duty Mercury Arc Rectifiers by W. O. Marti, Chief Engineer of the American Brown Boveri Elec. Corp. Film "Arc Welding Steel Pipe" from the Lincoln Electric Co., Cleveland was shown. Supper at the Elks' Club preceded the meeting. November 8. Attendance 45.

Baltimore

A. C. Distribution Network Systems, by C. J. Brosnan, Engineer, Westinghouse Elec. & Mfg. Co. Chairman presented report on Conference of Officers and Delegates at Swampscott, June 1929, and Executive Committee meeting District No. 2 held in Pittsburgh, October 7. October 18. Attendance 125.

Inspection trip through the works of the Baltimore Copper Smelting and Rolling Company. A. S. M. E. members joined the A. I. E. E. members for this inspection. October 19. Attendance 75.

Boston

Inspection trip of the port facilities of the Boston Harbor on the City Steamship *Michael J. Perkins*. The trip was accompanied by Messrs. Davis and McSorley of the Boston Chamber of Commerce who gave information about the Harbor which was followed by a general discussion of possible improvements. October 5. Attendance 185.

Cleveland

Joint meeting with the Illuminating Engineering Society in honor of Edison's Golden Jubilee, preceded by dinner furnished by the National Lamp Works. Addresses by John C. Lincoln, Chairman of Board of Directors, Lincoln Electric Co. on *Edison and His Inventions*, and R. W. Shenton, Managing Editor "Light Magazine," *Tribute to Edison*. Meeting concluded with a cineograph of Edison's life. Previous to the dinner Chairman T. D. Owens reported to his Advisory Committee on the October 7 District meeting. October 10. Attendance 160.

Connecticut

Harry A. Haugh, Jr., Vice-President, Automatic Signal Corporation, gave an informal talk on traffic conditions, illustrated with demonstrations of several pieces of apparatus typifying street intersections, etc. Dinner preceded meeting at University Club. November 7. Attendance 45.

Denver

Dinner guests of the Mountain States Telephone & Telegraph Co., followed by an inspection of the new building of that company. October 18. Attendance 100.

Detroit-Ann Arbor

H. H. Green, National Lamp Works of G. E. Co., spoke on Light's Golden Jubilee. Joint meeting with the Illuminating Engineering Society. October 8. Attendance 200.

Erie

Talk by M. V. Wright of the Mutual Telephone Co. on telephone systems. Mr. Ramuling of the Erie Lighting Co. related his company's practise on power generators and transmission. Mr. Moore, Erie County Electric Co. gave a talk and demonstration on electric illumination. October 15. Attendance 50.

Fort Wayne

High Voltage Research in Cooperation with Industry, by Prof. C. Francis Harding, Purdue University. Discussion followed. Change in By-laws proposed and carried. October 30. Attendance 80.

Houston

Inspection trip to the Freeport Sulphur Company at Hoskin, Texas in the afternoon, then to the Bryan Mound Mine,

followed by a dinner at the Tarpoon Inn, Freeport, as guests of the Freeport Sulphur Co. A talk on the production of sulphur was given by E. L. Nims, Asst. General Manager of that company. October 26. Attendance 27.

Iowa

Committee appointments announced. James H. Foote, Stevens and Wood, Jackson, Michigan, presented his paper, *Problems of Interconnection.* This paper covered experiences with power systems in Michigan. October 28. Attendance 58.

Kansas City

Man's Progress in Terms of Light, by Professor O. D. Hunt, Kansas State Agricultural College, in honor of celebration of Light's Golden Jubilee. A short talk was given by J. F. Porter, President of the Kansas City Pr. & Lt. Co., an Edison Pioneer. Replicas of all types of lighting from the early olive-oil lamp to the present day Mazda presented. October 14. Attendance 92.

Lynn

First meeting of the Season held in recognition of Light's 50th Anniversary. Charles C. Pierce of the General Electric Co. who was in intimate contact with Mr. Edison for some years spoke on his accomplishments. Professor Thomson, Edison Pioneer, outlined the parallel but separated courses of development followed by the incandescent lamp and the arc lamp. Refreshments served. October 21. Attendance 141.

Today's Research—Tomorrow's Engineering, by L. A. Hawkins, Executive Engineer, General Electric Co. Research Laboratory. November 6. Attendance 120.

Mexico

Scott Lynn, Vice-President and General Manager of the Sangamo Electric Co. of Canada gave a lecture on *Electrical Metering Apparatus.* Elections and committee appointments announced. October 8. Attendance 27.

Annual Banquet at Hotel Mancera. October 19. Attendance 31.

Milwaukee

Meeting held in celebration of Light's 50th Anniversary. A. N. Brown, District Engineer, Westinghouse Elec. & Mfg. Co., talked on *Edison and His Achievements,* using slides to illustrate the steps in the development of the electric lamp and the illuminating effects possible with the modern electric lamp. History of Edison's life and his achievements reviewed by Mr. Brown. A. C. Langstadt read paper on the first central power station in operation at Appleton, Wis. A. R. Schmidt of Milwaukee enumerated experiences with the original Edison Company. Dinner preceded meeting. October 16. Attendance 150.

Minnesota

Wood Poles and Wood Preservation, by J. P. Wentling, Director Research Division, Western Red Cedar Association. October 28. Attendance 32.

New York

Power Group. Talks by H. C. Forbes of the New York Edison Co. and C. M. Gilt of the Brooklyn Edison Co. General meeting subject was *Generation and the Development of Generators.* October 30. Attendance 250.

Transportation Group. Guy C. Hecker, General Secretary of the American Electric Railway Association, gave a general outline of the developments in the electric railway field. A. O. Austin, Control Engineer, Westinghouse Elec. & Mfg. Co., described the technical features of modern control apparatus and attempts being made to develop street cars with greatly increased acceleration possibilities and more powerful motor equipment to meet modern traffic conditions. Two reel film on traffic conditions in various cities shown through the courtesy of the R. C. A. Photophone and A. E. R. A. November 4. Attendance 100.

North Carolina

Adoption of By-Laws. *Waterville Development of Carolina Power & Light Company,* by J. H. Paget, Supt. of Power, Carolina Power & Light Co., Raleigh, N. C.

New Era in Ship Propelling Machinery, by F. V. Smith, Federal and Marine Dept., General Elec. Co., Schenectady, illustrated with slides.

Hydroelectric Development in Canada, by W. S. Lee, Vice-President and Chief Engineer, Duke Power Co., Charlotte, N. C.

Lightning Disturbances, by F. W. Peek, Jr., Consulting Engineer, General Electric Co., Pittsfield, Mass., illustrated by slides and motion pictures.

Vice-President W. S. Rodman announced future activities and spoke on the relation of the Section to the Institute. Informal dinner. October 23. Attendance 95.

Inspection trip to the Riverbend Steam Station and Mountain Island Hydroelectric Station of the Duke Power Company. October 24.

Philadelphia

Joint meeting with the Illuminating Engineering Society. Professor Charles F. Scott, Yale University, presented a paper on *Fifty Years of Light and Power.* October 21. Attendance 200.

Pittsburgh

Joint meeting with the Engineers' Society of Western Pennsylvania and the Institute of Radio Engineers. *Making Sound Visible and Light Audible,* by Dr. John B. Taylor, Consulting Engineer, General Electric Co. Informal discussion followed. October 15. Attendance 440.

Portland

M. E. Noyes, Sales Engineer, Aluminum Co. of America, presented *New Developments in Mechanical Features of Transmission Lines,* illustrated with moving pictures. Aluminum cables were exhibited. *The New 110-Kv. Lewis River Transmission Line,* by E. F. Pearson, Electrical Engineer, Northwestern Electric Co. General discussion and buffet lunch followed. October 21. Attendance 108.

St. Louis

C. Carter Lewis, Lighting Engineer of the Union Electric Light & Power Co., gave an interesting talk, tracing the development of lighting as applied to the home from the earliest prehistoric times up to the present. Models to show the various developments in home lighting were presented. Prizes awarded lady guests. October 16. Attendance 75.

Schenectady

Reading of minutes of Annual meeting. Announcement of election of officers. The evening was devoted to a smoker celebrating the occasion of Light's Golden Jubilee. Two-reel film "The Benefactor" was shown. Smokes, refreshments, and musical numbers provided. October 12. Attendance 225.

The Fishing Banks and Fishing, by Bassett Jones, Consulting Engineer. Mr. Jones discussed the details of fishing and the geology of the fishing banks off Nova Scotia. Dinner preceded meeting. November 1. Attendance 200.

Seattle

Chairman L. N. Robinson read minutes of four previous meetings. Ray Rader gave report on the Summer Convention at Swampscott. A short talk was given by Professor R. G. Tyler, Dean of the Engineering College at the University of Washington. Lieut. L. Dreller, U. S. N., spoke on *The Propulsion and Other Electrical Equipment of the New Airplane Carrier, U. S. S. Lexington.* Coffee and sandwiches served. October 15. Attendance 75.

Springfield

Report of meeting of Executive Committee, District No. 1, held October 9 read. Future Section meetings announced. H. Schroeder, General Engineer of the Edison Lamp Works, Harrison, N. J., spoke on Edison's development of the incandescent lamp. Refreshments served. October 14. Attendance 50.

Syracuse

Executive Committee meeting. Resignation of former Chairman McCann accepted. F. E. Verdin chosen as Chairman for the remainder of the term. Charles W. Henderson elected Secretary. Section plans discussed. September 30.

Sound Pictures—Their Recording and Reproduction, by Philip C. Jones of the Technical Staff of Bell Telephone Laboratories. Sound pictures projection, films, and slides used to illustrate the lecture. October 28. Attendance 349.

The Quest of the Unknown, by Professor Harold B. Smith, President of the Institute. Dinner tendered to Professor Smith by the Section. November 1. Attendance 117.

Toledo

D. J. Finn of the General Electric Co. spoke on Light's Golden Jubilee. Ed. Thomas related experiences on experimental work while working for Mr. Edison in 1888. Five minute radio talks given daily by Messrs. Featherstone, Dubs, Rabbe, and Neuber.

Toronto

Paper presented by A. R. Wells on the *Use of Graphic Meters in Industry*. Mr. Wells described the use to which graphic meters might be put, their construction, and troubles likely to arise, and gave data relative to their correct connections into power circuits. Discussion followed. October 11. Attendance 80.

D. M. Jones of the General Electric Co. spoke on automatic frequency control and the difficulties experienced in securing satisfactory frequency regulation on systems of any magnitude. Discussion followed. October 25. Attendance 56.

Urbana

Electrical Engineering Applications of X-Rays, by Dr. H. L. Clark, Professor of Chemistry at the University of Illinois. October 9. Attendance 100.

R. E. Doherty, Consulting Engineer, General Electric Co., Schenectady, N. Y. spoke on *Constant Linkage Theorem*. October 25. Attendance 130.

Utah

C. B. Shipp presented a report of the Summer Convention at Swampscott. *Electric Motors and Their Proper Application*, by L. Bradenburger, illustrated with lantern slides. Five reel film entitled "From Mine to Consumer—the Story of Anaconda" presented. October 14. Attendance 26.

Vancouver

The Quest of the Unknown, by Professor Harold B. Smith, President of the A. I. E. E. with lantern slides. Dinner at which President Smith spoke on Institute activities preceded the meeting. August 20. Attendance 45.

Inspection trip to Buntzen Hydroelectric Development, Plants 1 and 2, B. C. Electric Railway Co., Ltd. Luncheon at Wigwam Inn preceded the inspection. September 14. Attendance 19.

System Stability, by I. H. Summers, General Electric Co., Schenectady, N. Y. September 30. Attendance 30.

Washington

Former Section Chairman, Professor L. D. Bliss gave a report of the Swampscott convention. Film "The Story of Copper, From Mine to Consumer." Dinner preceded meeting. October 8. Attendance 153.

Worcester

Personal reminiscences of Edison by Dr. A. E. Kennelly, Harvard University. October 21. Attendance 30.

A. I. E. E. Student Activities

ELECTRICAL SHOW HELD AT MONTANA STATE COLLEGE BRANCH

The Montana State College Branch celebrated Light's Golden Jubilee by having an Electrical Show on the evening of October 21, 1929. Preparations were made by the juniors and seniors and the exhibits included a wide variety of interesting and instructive equipment and demonstrations. About twenty-five exhibits were provided including artificial lightning and television equipment.

An address was given by Professor C. F. Bowman of the Electrical Engineering Department, on the correct use of light. This address was illustrated fully with demonstrations of various types of correct and incorrect lighting.

At 11:00 a. m. on Tuesday, October 22, an address on the "Romance of Light" was given by H. Plumb, Consulting Engineer of the General Electric Company, and in the evening of that date he gave a second address entitled "Painting with Light."

PAST BRANCH MEETINGS

Alabama Polytechnic Institute

Minutes of previous meeting read and approved. Talk by Paul Brake, Student, on "Summer Work at Broadcasting Station W A P I." October 17. Attendance 18.

Failure of Bearings at Bartletts Ferry Station, by R. F. Ham, Student; *The Electric Power Industry in Japan*, by J. A. Willman, Student; and *Steroscopic Motion Pictures*, by W. R. Colman, Student. October 24. Attendance 26.

Armour Institute of Technology

The Electrification of Steam Railroads in Europe, by H. H. Field, Public Service Co. of No. Illinois, illustrated with slides. Joint meeting with local chapter of Western Society of Engineers. Committee appointments announced. November 1. Attendance 90.

Brooklyn Polytechnic Institute

X-Rays, by R. Muniz, illustrated with slides. Three-reel film, "The Single Ridge" describing the manufacture of insulated wire by the Okonite Co. October 23. Attendance 90.

California Institute of Technology

Professor R. W. Sorensen, Counselor, spoke on the activities of the A. I. E. E. E. C. Lee described the Pacific Coast Convention at Santa Monica in September. October 15. Attendance 34.

University of California

Branch activities discussed. Two-reel film describing student testing at the Schenectady plant of the General Electric Co. Refreshments served. October 23. Attendance 98.

Carnegie Institute of Technology

Film—*The Fabrication of Copper*, loaned by the U. S. Bureau of Mines. *The Trend in Public Utility Rate Making*, by L. B. McConaghy, Student. Refreshments were served. November 6. Attendance 86

Case School of Applied Science

Committee appointments announced. Talks by Professors H. B. Dates, (Counselor) P. L. Hoover, R. C. Putnam, and G. A. Mills on past summer experiences. Dinner preceding meeting. October 15. Attendance 34.

Clarkson College of Technology

Inspection of Allen's Falls and Parishville Hydroelectric Stations. Professor A. R. Powers, Counselor, and several Students gave short talks. Dinner. October 31. Attendance 33.

Inspection of Hydroelectric Stations at Sugar Island, Hanawa Falls, and Brown's Bridge. October 15. Attendance 51.

Film depicting Edison's life. October 21. Attendance 69.

Clemson Agricultural College

Buying Supplies for a Large Electrical Concern, by C. E. Jarrard, Student; *Radio Interference from Line Insulators*, by E. E. Hembree, Student; *Current Events*, by C. G. Smoak, Student; and *Values*, by W. N. Coleman, Student. October 17. Attendance 18.

Life of Elihu Thomson, by J. M. Prim, Student; *The Engineer, Practical Idealist*, by E. H. Mazyck, Student; *New Ways for Oil in Industry*, by J. J. McFadden, Student; *Qualities of an Engineer*, by W. D. Craig, Student; *Current Events*, by J. L. Chapman, Student. Luncheon. November 7. Attendance 26.

Colorado Agricultural College

Business Meeting. L. Haubrich elected Secretary. Professor H. G. Jordan, Counselor, gave a talk on the A. I. E. E. September 23. Attendance 17.

Robert F. Bonney, Educational Director of the M. S. T. & T. Co., gave an illustrated lecture on Life of Edison and Light's Golden Jubilee. October 14. Attendance 101.

Prof. L. S. McDonald, Head of the Mathematics Dept. gave a lecture on Astronomy. October 29. Attendance 17.

University of Colorado

Talks by Dean H. S. Evans and Professor W. C. DuVall, Counselor. Film-slide lecture entitled *Light's Golden Jubilee*. Manuscript read by Geo. B. Steuart, Student. October 16. Attendance 85.

Engineering Thinking, by N. R. Love, Chief Engineer, Denver Tramway Co. and Secretary Denver Section. Discussion followed. Refreshments served. November 6. Attendance 65.

Cooper Union

Election of Officers. October 16. Attendance 9.

Cornell University

Get-together meeting. Professor R. F. Chamberlain outlined activities of the A. I. E. E. Talks by several professors and students. Refreshments served. October 11. Attendance 55.

University of Denver

Inspection of the new building of the Mountain States Tel. & Tel. Co. October 30. Attendance 15.

Drexel Institute

The Unforeseen in Engineering, by Professor E. O. Lange, Counselor. Talk by Dean Disque. Film—*Hydroelectric Power Production in the New South.* Sandwiches and coffee served. November 4. Attendance 25.

University of Florida

New members solicited. Talks by faculty and student members on attendance at A. I. E. E. meetings. October 14. Attendance 25.

Television, by L. R. Bassett, Student. R. T. Meeker, Student, gave a talk on summer experiences with the Florida Pr. & Lt. Co. Musical numbers. November 4. Attendance 43.

Iowa State College

Students of the Iowa State College Branch joined members of the Iowa Section at their meeting in Des Moines. October 28. Attendance 25.

Smoker. Talks by Harold Stahl, Branch President, B. S. Willis, and Prof. F. A. Fish, Counselor, on the activities of the A. I. E. E. Refreshments served. November 6. Attendance 122.

Kansas State College
(EVENING SECTION)

Current events discussed by Mr. Butler. Talks on summer experiences with the Bell Telephone Co. and Westinghouse Elec. & Mfg. Co. by K. W. Ernst and B. E. Atwood, respectively. October 3.

C. J. McMullin discussed current events. Technical talk on low voltage networks by L. R. Kirkwood. October 17.

Technical and current events reviewed by Arlo Steel and J. W. Wilhite. Talk on sound pictures by I. R. Stenzel. Film—"Building New York's Newest Subway." October 24.

Kansas State College
(AFTERNOON SECTION)

Current events, by R. Sage. Technical talk on Cuprox rectifiers by Art Owen. G. L. Quigley gave talk on *Reproduction of Sound in Movies.* Film—"Building New York's Newest Subway." October 31. Attendance 70.

Current events, by H. L. Winston. Talk by R. B. Heckert on methods of blasting. L. C. Paslay discussed Vacuum Tube Research. Film—"Driving the Cascade Tunnel." November 7. Attendance 54.

University of Kansas

Talks on summer experiences by Messrs. Leonard, Miller, and Reinhold, Students. Musical numbers furnished. October 17. Attendance 65.

New By-laws adopted. *The White Way System of St. Louis,* by Maurice A. Reagan, Student. Films—"Making of Steel," and "Wizardry of Wireless." October 30. Attendance 70.

Lafayette College

Flames from Electric Arcs, by Alfred Gano. October 19. Attendance 11.

Lehigh University

Smoker. Professors Barker and Beaver gave informal talks. Two-reel film—"Hydroelectric Power Production in the New South." Refreshments served. October 24. Attendance 85.

University of Maine

Slides commemorating Light's Golden Jubilee presented. Professor Barrows talked on the history of the incandescent lamp. Refreshments served. October 23. Attendance 25.

Marquette University

Relation of the Engineer to Industry, by S. H. Mortensen, Allis-Chalmers Mfg. Co. Professor Douglass reported on the number of Student papers received, some of which will be presented at the Chicago District Meeting. October 3. Attendance 55.

Massachusetts Institute of Technology

N. J. Darling, Works Manager of the G. E. Co., Lynn, discussed the opportunities and problems of engineering graduates in industry. Moving pictures showing some of the manufacturing processes of the General Electric Co. were shown. Dinner preceded meeting. October 31. Attendance 309.

Michigan State College

Two films—"The Potters Wheel" and "The Conductor." Six Students gave talks on summer experiences. Committee appointments announced. Refreshments served. October 8. Attendance 41.

University of Michigan

Election of officers. Prof. B. F. Bailey, Counselor, spoke on the aims and activities of the Institute. October 23. Attendance 35.

H. J. Iler, Bell Telephone Co., discussed the new exchange which has been installed on the campus. Talk by Prof. A. D. Moore on contact between seniors and leading electrical companies. November 6. Attendance 40.

Mississippi A. & M. College

W. F. Barksdale, Branch Chairman, related experiences pertaining to his employment with the Chicago Central Station Institute. Committee appointments announced. October 17. Attendance 22.

Missouri School of Mines and Metallurgy

Election of officers. Prof. I. H. Lovett, Counselor, spoke on the privileges and advantages of membership in the A. I. E. E. Discussion of plans for future meetings. November 6. Attendance 16.

University of Missouri

Election of officers. *A. I. E. E. and its Relation to the Student,* by Professor M. P. Weinbach, Counselor. *Aims of the Student Branch,* by Professor A. C. Lanier. Talks by J. M. Manley and L. E. Howard on experiences with the G. E. Co., Schenectady. October 3. Attendance 19.

Power Transmission Line Construction and Location on the West Coast, by Prof. Harry Rubey. Prof. M. P. Weinbach, Counselor, discussed plans for the Student Convention of the 7th District. November 6. Attendance 28.

Montana State College

The Welding of Metals with The Atomic Hydrogen Flame, by R. A. Weinman, given by Lowell Kurtz, Student;

Lightning Arrester Grounds Testing, by Edward Beck, Westinghouse Elec. & Mfg. Co., given by Homer Morton, Student. October 17. Attendance 156.

Transformer Neutral Reactors Reduce Breaker Duty, from *Electrical World,* Sept. 28, 1929, presented by Robert Jones, Student. October 24. Attendance 156.

750-Kw. High-Voltage Rectifier, by I. J. Kaar of the G. E. Co., given by Earle Rudberg, Student;

Neon Light Properties, by Leo Beck, Chief Engineer, Claude Neon National Laboratory, given by Carl Plumlee; and

Suggestion for a Simple Method for Keeping the Transmitter Disks in Step, by Thomas W. Benson, given by W. Hadley Queen. October 31. Attendance 159.

Economy of Buried Cables, by F. E. Smith, Chief Engineer, Nebraska Power Co., given by Ronald Crumley, Student;

Stubbing Poles Reduces Line Cost, by C. J. Marple, given by Roy Bjork, Student; and

D-C. Railway Substations for the Chicago Terminal Electrification—Illinois Central Road, by A. M. Garrett, given by James Giudici, Student.

University of Nebraska

Engineering in Business, by C. D. Robinson, Chief Engineer, Metropolitan Utilities District, Omaha. Joint meeting with A. S. M. E. members. October 26. Attendance 50.

Crystal Control, by Louis F. Lench. Harry E. Cook, Northwestern Bell Tel. Co., gave talk discussing the prospects for student engineers. Talks by W. E. Huddleston and James Kleinkauf, Students, relating experiences during summer employment. November 6. Attendance 37.

Newark College of Engineering

J. A. Hodges, Sales Manager, National Lamp Works of General Electric Co., related Edison's life. Inspection of the airport arrow on the laboratory building. October 21. Attendance 25.

University of New Hampshire

Informal talks by Students relating experiences during summer employment. September 28. Attendance 45.

R. Ballard, Student, spoke on summer experiences as radio man in the Naval Reserve. A. Whitcomb, Student, described interesting features in the Bellows Falls, Vt., Power Plant. October 5. Attendance 45.

J. J. Donnelly, Student, read paper on the Incandescent lamp, illustrated by lantern slides. R. Osgood, Student, spoke on his summer work as metal analyzer in a foundry. October 19. Attendance 49.

J. Arren spoke on *The Electrification of the Boston, Revere Beach, and Lynn Railroad.* W. Adams, Student, gave history of alternating current development in the U. S. F. Austin, Student, spoke on the use of space heaters in the home. October 23. Attendance 50.

University of New Mexico

First meeting of the Branch. *Electrolytic Rectifiers*, by W. I. Abbott, Branch Secretary. Discussion followed. October 29. Attendance 18.

Business meeting. Committee officers appointed. November 5. Attendance 10.

College of the City of New York

Film—"The Single Ridge." October 10. Attendance 12.

Business meeting. October 17. Attendance 12.

R. Fassnacht, Branch Chairman, spoke on the opportunities and benefits of membership in the Institute. November 7. Attendance 21.

Refractory Insulating Materials, by Mr. Fenwick, Chairman A. S. M. E. Branch. Joint meeting of the A. I. E. E., A. S. M. E., and Chemical Engineers. November 14. Attendance 30.

North Carolina State College

Executive business. Film—"From Mine to Consumer." October 15. Attendance 35.

H. W. Horney, Branch Chairman reported on the Section meeting in Charlotte. Oct. 23-24. Film "Behind the Button." November 5. Attendance 60.

University of North Carolina

Informal talks by Dean Braune, and Professors Bason, Lear, and Winkler on the advantages of A. I. E. E. membership. October 3. Attendance 33.

Problems of Grecian Architecture, by Dr. J. P. Harland, illustrated with slides. October 31. Attendance 26.

North Dakota State College

Light's Golden Jubilee, by Lewis Nelson and Walter Nelson, Students. Refreshments and music. October 24. Attendance 97.

University of North Dakota

Circuit Breaker Problems, by E. K. Reed, Westinghouse Elec. & Mfg. Co., illustrated with lantern slides. October 15. Attendance 19.

Northeastern University

Theory and Use of Submarine Signal Devices, by Horatio Lamson, General Radio Co. Discussion followed. October 29. Attendance 112.

University of Notre Dame

Airport Illumination, by Mr. Coomes, Student;
Life of Maxwell, by Mr. Scanlon; student, and
Low-Voltage Networks, by Mr. Diedrich, Indiana & Michigan Electric Co. Refreshments served. October 7. Attendance 55.

The Life of Dr. Lee de Forest, by Mr. Mohler, Student. John Mullane of the R. C. A. Photophone Corp. explained the principles of R. C. A. Photophone. Committee appointments announced. October 21. Attendance 87.

Ohio Northern University

Seamless Steel Tubes, by Louis Goodman, Student. October 10. Attendance 32.

Street Illumination in St. Louis, by E. Pankow, Student. October 24. Attendance 23.

Ohio State University

Smoker. Several talks by faculty members regarding A. I. E. E. benefits and opportunities. October 10. Attendance 60.

Oklahoma A. & M. College

Walter Hass, Student, spoke on the Tulsa Rolling Mills Co. M. L. Hendrickson gave résumé of his summer experiences with Shell Petroleum Corp. Charles Fry, Student, discussed methods used by Okla. Gas. & Elec. Co. Drafting Dept. October 31. Attendance 22.

Pennsylvania State College

Personal Recollections of Dr. Steinmetz, by R. E. Doherty, G. E. Co. October 8. Attendance 86.

Smoker. Talks by Professors Doggett, Stavely, and Messrs. Crosby, Powel, and Robertson. A. D. Marshall, Asst. Secy., G. E. Co., visiting speaker, gave an interesting talk. October 15. Attendance 104.

Talk by Mr. Evans, Asst. Vice-President of Bell Telephone Co. of Pa. Talk by Dean Sackett. Election of E. L. Johnston, Junior Vice-President, and S. A. Adler, Assistant Secretary. November 6. Attendance 18.

Princeton University

Election of officers. Purpose and By-laws of the Branch described. October 11. Attendance 14.

Fortifications of the Swiss Railroads, by R. M. Schafer, Student;
Pilatron Tubes, by H. W. Dodge, Student; and
Testing of Underground Cables, by C. F. Nesslage, Student. October 31. Attendance 13.

Purdue University

C. K. Huxtable presented paper on Thomas A. Edison. Illustrated talk given by a student on the life and history of Edison. October 22. Attendance 250.

Rensselaer Polytechnic Institute

Dr. Robb spoke on Edison. Demonstrations of old generators, and a replica of Edison's first lamp was exhibited. October 21. Attendance 95.

The Stock Market, by Professor Spafford, Dept. of Business Administration. Discussion followed. November 12. Attendance 110.

Rhode Island State College

Film—"Hydroelectric Power Production in the New South." October 16. Attendance 117.

Rose Polytechnic Institute

Light's Golden Jubilee, by D. F. Williams, illustrated. October 24. Attendance 18.

Rutgers University

General discussion. September 24. Attendance 17.
Election of officers: G. E. Weglener, President; F. Kent, Vice-President. October 1. Attendance 18.

Radio Corporation of America, Bound Brook, N. J. Station, by A. Suone, Student; and
132-Kv. Underground Cable, United Electric Lt. & Pr. Co. New York, by F. H. Kent, Student. October 8. Attendance 20.

Committee appointments. Prof. Creager, Counselor, spoke on the activities of the Institute. October 15. Attendance 18.

South Dakota School of Mines

Talks on summer experiences by Messrs. Walkling, Donaldson, Laws, and Sattler, Students. Prof. Kammerman, Counselor, gave a short talk. October 24. Attendance 25.

Talk by M. E. Murphy of the Western Electric Co. on the development of talking pictures and the installation of Vitaphone equipment in the theatres in England. November 7. Attendance 57.

University of Southern California

Summer experiences related by Messrs. J. McCarter, L. Slezak, G. Robertson, and John Wardell, Students. October 2. Attendance 32.

William Hoag, General Electric Co., related experiences as a student engineer while at East Pittsburgh. October 9. Attendance 36.

Past experiences related by Ivan Summers, General Electric Co. October 23. Attendance 39.

Electrical Therapy, by Sidney Rosen, Student; and *Telephoto*, by Edward McCarter, Student. October 30. Attendance 32.

My Experiences with the Westinghouse Co., by Gilbert Dunstan, faculty member. November 6. Attendance 30.

Stanford University

Election of Douglas H. Ring as Branch Chairman. October 7. Attendance 9.

Chairman Ring spoke on the Institute's attitude toward the Student. Prof. Morgan, Counselor, outlined some of the papers given at the Conference on Student Activities at the Santa Monica convention. Dr. Ryan gave a short history of the Institute. October 24. Attendance 32.

Film depicting the work by student engineers of the Test Course at the General Elec. Co. October 30. Attendance 28.

Syracuse University

Neon Tubes, Their Construction and Their Applications, by Alfred E. Davies, Student. November 12. Attendance 9.

University of Tennessee

Film—"The Single Ridge." October 23. Attendance 20.

Talk by J. M. Brooks on electrical devices used on automobiles and airplanes. A. M. Howery discussed the functions of a broadcasting station. November 6. Attendance 18.

Texas A. & M. College

Effects of Loading on the Speed of Transmission of Deep Sea Cables, by D. P. Tunstall, Student. Film—"Speeding up our Deep Sea Cables." November 8. Attendance 87.

University of Texas

Two films—"Back of the Button" and "The Development of the Telephone." The purpose of Student enrolment discussed. October 10. Attendance 33.

University of Utah

Frank Young, Jr., Student, read manuscript on Edison's life. Alvin Fagergren, Student, spoke on Edison's life. October 22. Attendance 59.

Joint meeting with A. S. M. E. Branch. Film showing the building of the longest tunnel in America presented. November 5. Attendance 42.

University of Vermont

Education for Engineers, taken from the April and September issues of the A. I. E. E. JOURNAL, presented by F. E. Beckley, Student. October 1. Attendance 14.

Virginia Military Institute

Film—"Hydroelectric Power Production in the New South." November 8. Attendance 95.

Film—"Arteries of Industry." November 12. Attendance 40.

University of Washington

The Outlook for the Electrical Engineering Student, by Dr. C. E. Magnusson. October 11. Attendance 28.

E. D. Engle, Student, presented a report on the 1929 Pacific Coast Convention of the A. I. E. E. October 18. Attendance 21.

Television, by J. M. Wallace, Student. J. M. Wallace elected Junior Representative to the Engineering Council. October 25. Attendance 19.

Mr. Jenner, graduate student, related experiences while associated with the Goodrich Rubber Co. Branch activities discussed. November 1. Attendance 18.

Washington University

Plans for future meetings discussed. October 10. Attendance 18.

Talk by R. W. Brewster, Student, on summer experiences. Joyce Pittsbury elected Vice-Chairman. October 31. Attendance 20.

West Virginia University

The following papers were presented by Students: *Electrical Status of Power Generation*, by C. E. Moyers, Chairman; *Small Loads can be Economically Connected to High-Tension Lines*, by W. H. Sutton; *Burned Out Incandescent Lamps*, by P. J. Johnson; *First Aid in Transformation Continuation of Large Transformers*, by E. D. Harris; *Ammeter for Measuring Motor Starting Currents*, by C. A. Bowers; *The DuPont Company, and Their Methods of Handling Heavy Currents*, by V. O. Whitman. October 14. Attendance 40.

The following papers were presented by Students: *Future Street Car Control*, by R. C. Warder; *Accurate Load Forecasting*, by R. H. Pell; *Measuring of Pulsating Currents*, by E. Milam; *Edison's Life*, by F. E. Watson; *Welding with Atomic-Hydrogen Flame*, by J. E. Neucomer; *Advantages of Electric Shovel Over Steam Shovel*, by A. H. Goddin; *Million Volt Light Producer*, by C. F. Stewart; *Light Weight Railway Cars can be Obtained from Aluminum Alloys*, by M. Suppa. October 21. Attendance 41.

The following papers were presented by Students: *Daniel Guggenheim Graduate School of Aeronautics*, by S. B. Wolfe; *Lighting St. Louis*, by H. W. Unger; *Electric Transmission versus Coal Transportation*, by H. O. Webb; *Toll Lines*, by C. E. Moyers; *Theory of Bowing in Telephone Cables*, by G. H. Hollis; *Methods of Splicing Large Cables*, by C. J. O'Leary; *Detroit-Canada Vehicular Tunnel*, by F. E. Houck; *The Gas-Electric Bus*, by G. S. Garrett. October 28. Attendance 41.

The following papers were presented by Students: *Welding of Ferrous and Non-Ferrous Metals by the Atomic-Hydrogen Flame*, by P. J. Johnson; *Telephone Circuits for Program Transmission*, by J. S. Merritt; *Electrifying 8000 Farms*, by E. D. Harris; *Powdered Coal Plant*, by A. H. Huggins; *The Fundamental Requirements of the Modern Railway Car*, by G. W. Pride; *Experimentations on Seadromes*, by M. P. Hooker; *Requirements of Electrical Insulation*, by A. Dikea. November 4. Attendance 46.

The following papers were presented by Students: *Part of Electricity in the Manufacture of Cement*, by A. F. Fervier; *Regulation of a 30,000-Kv-a., 13,000-Volt Line*, by R. H. Pell; *Foltinger Torsion Meter*, by E. Milam; *Hydrogen a Successor to Air*, by G. A. Stemple; *Effects of Corona in Different Gasses on Insulation*, by C. A. Bowers; *Lighting of Airways and Airports for Night Flying and Requisites*, by V. O. Whitman; *Development of Insulating Oils*, by J. E. Neucomer; *Ammeters for Starting Motors*, by A. H. Goddin. November 11. Attendance 45.

University of Wisconsin

Professor Jansky, Counselor, spoke on Branch activities. Two films—"Anaconda Copper" and "Building New York's Newest Subway." October 10. Attendance 65.

Yale University

Meeting held to celebrate Light's Golden Jubilee. Illustrated talk on "The Development of the Electric Light," by F. H. Eastman, Chairman. Refreshments provided. October 21. Attendance 40.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these Founder Societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES, OCTOBER 1-31, 1929

Unless otherwise specified, books in this list have been presented by the publishers. The Societies do not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

ADVANCED LABORATORY PRACTICE IN ELECTRICITY AND MAGNETISM.

By Earle Melvin Terry. 2d edition. N. Y., McGraw-Hill Book Co., 1929. 318 pp., illus., diagrs., tables, 9 x 6 in., cloth. $3.00.

A course of experiments given to third-year students of electrical engineering at the University of Wisconsin, which includes, in addition to the usual work in electrical measurements.the discharge of electricity through gases, radio activity and thermionics.

DIE AKKUMULATOREN.

By W. Bermbach. 4th edition. Berlin, Julius Springer, 1929. 214 pp., illus., 9 x 6 in., paper. 8,50 r. m.

Professor Bermbach has thoroughly revised his book by incorporating the developments of the past ten years in storage battery practise, especially concerning rectifiers and the uses of accumulators. The book gives an excellent survey of theory and practise, comprehensive enough for ordinary needs, but not too detailed.

APPLIED INORGANIC ANALYSIS.

By W. F. Hillebrand and G. E. F. Lundell. N. Y., John Wiley & Sons, 1929. 929 pp., tables, 9 x 6 in., cloth. $8.50.

This new work will be welcomed by every analytical chemist. Starting with an instructive discussion of apparatus, reagents and operations, the book then takes up the determination of the elements, the analysis of silicate and carbonate rocks and of soda-lime glass and high-alumina refractories. Emphasis is placed upon the preparation of the solution for the required determination.

The book is based upon the broad experience of its authors at the Bureau of Standards, and includes the substance of Dr. Hillebrand's well-known Bulletin on rock analysis.

BEGINNINGS OF TELEPHONY.

By Frederick Leland Rhodes. N. Y., Harper & Bros., 1929. 261 pp., illus., port., 10 x 6 in., cloth. $4.00.

Bell's invention, the attacks on his patents, and the beginnings of the microphone transmitter, the overhead-wire plant, the telephone cable, loaded lines, the switchboard, the phantom circuit and long-distance lines are some of the topics that Mr. Rhodes discusses. His purpose is to give workers in telephony familiarity with the problems of pioneers in the field, to show how these were solved and to indicate the contributions of the various workers. His account of the litigation that arose over Bell's patents is especially good.

BLUEPRINT READING.

By Joseph Brahdy. N. Y., McGraw-Hill Book Co., 1929. 199 pp., illus., diagrs., tables, 9 x 6 in., cloth. $2.00.

A course in the reading of working drawings, intended for those engaged in manufacturing industries and for students in trade schools.

DIRECT CURRENTS.

By Carl Edward Magnusson. N. Y., McGraw-Hill Book Co., 1929. 495 pp., illus., diagrs., 9 x 6 in., cloth. $4.50.

A presentation in logical order of the basic principles of the electric circuit and of the characteristics of d-c. machines, apparatus, and distribution systems. Forms the first of a series of texts covering the fundamental laws of electrical phenomena as applied to engineering problems, the other volumes of which are "Alternating Currents" and "Electric Transients" by the same author.

DIRECTORY; FORGING, STAMPING AND HEAT TREATING PLANTS, 1928-29.

Pittsburgh, Steel Publications, Inc. 1929. 293 pp., 8 x 5 in., fabrikoid. $7.50.

This directory gives the officers, equipment, products and railroad connections of the various companies, as well as a geographic index to them. Users of forgings and stampings, as well as dealers in plant supplies and machinery, will find this a useful guide.

ELECTRIC STREET LIGHTING.

By Charles J. Stahl. N. Y., John Wiley & Sons, 1929. 228 pp., illus., diagrs., 9 x 6 in., cloth. $3.50.

Readers wishing a broad working knowledge of modern practise in the design of installations for lighting streets, will find here a statement of the most essential information, based on the author's experience. Modern requirements and current methods of design, the selection and use of suitable equipment are discussed concisely and practically.

ELECTROMAGNETIC PROBLEMS IN ELECTRICAL ENGINEERING.

By B. Hague. Lond. & N. Y., Oxford University Press, 1929. 359 pp., diagrs., 10 x 6 in., cloth. $10.50.

Recent interest in the real physical nature of the internal reactions that occur within electrical machinery have prompted attempts to develop the theory of dynamo-electric machinery as a branch of electromagnetic theory. The present book is a contribution to this study.

Part one lays down the general theory of electromagnetism in a form suited to the requirements of engineers and occupies a middle ground between ordinary text-books of electricity and magnetism, and those on the design and operations of electrical machinery in which the engineering aspect is insisted upon. In part two, the principles laid down in part one are applied to the solution of a number of important electrotechnical problems, including the magnetic field and mechanical forces in non-salient pole machinery; the field within slots and between salient poles; the leakage field in transformers; the magnetic field of thick conductors with various forms of section; and the forces acting upon switchgear.

ELECTRON PHYSICS.

By J. Barton Hoag. N. Y., D. Van Nostrand Co., 1929. 208 pp., diagrs., tables, 9 x 6 in., cloth. $3.00.

Intended to initiate students of physics to such concepts as

"electrons," "alpha, beta and gamma rays," "photoelectric effect," etc., by experiments that require only simple apparatus. The book presents these concepts simply, accompanied by the experiments. Follows a course in radioactivity and discharge through gases given at the University of Chicago.

ENGINEERING MECHANICS.

By William Brooke and Hugh B. Wilcox. Bost., Ginn & Co., 1929. (Engineering Series). 320 pp., 9 x 6 in., cloth. $3.20.

A concise course in fundamental principles, intended for students of engineering with some knowledge of the calculus. Covers statics, kinematics and dynamics. Many problems are provided.

FORTY YEARS WITH GENERAL ELECTRIC.

By John T. Broderick. Albany, N. Y., Fort Orange Press, 1929. 218 pp., ports., 8 x 5 in., cloth. $2.50.

Mr. Broderick's little book deals with the growth of the company, with some of the men who made it, and with various achievements in invention and management. He presents the Company as a living organism, showing the influences that have molded it and directed its growth.

HEAVISIDE'S OPERATIONAL CALCULUS AS APPLIED TO ENGINEERING AND PHYSICS.

By Ernst Julius Berg. N. Y., McGraw-Hill Book Co., 1929. (Electrical Engineering Texts). 214 pp., diagrs., 8 x 5 in., cloth. $3.00.

Professor Berg's book, much of which has appeared in the General Electric Review, is based upon an extensive experience in demonstrating Heaviside's methods to students of electrical engineering. It provides a clear account of his calculus and a demonstration of its application to the study of transient phenomena.

INDUSTRIAL ACCOUNTING; Control of Industry through Costs.

By Thomas Henry Sanders. N. Y., McGraw-Hill Book Co., 1929. 371 pp., forms, 8 x 6 in., cloth. $4.00.

The innovations in Professor Sanders' discussion of accounting are the extensive use of case material and the concentration of attention upon the objectives of cost accounting rather than upon the mechanics of cost gathering. The book seeks to conform to the modern tendency to curtail the volume of the routine gathering of figures and, while maintaining the current flow of essential control figures, to have the cost department free to investigate any matters of special interest at any time.

INTRODUCTION TO PHYSICAL OPTICS.

By John Kellock Robertson. N. Y., D. Van Nostrand Co., 1929. (University Physics Series). 422 pp., plates, diagrs., tables, 9 x 6 in., cloth. $4.00.

Aims to provide a comprehensive introduction to the subject which shall be neither elementary or advanced, but will lay a thorough foundation for subsequent work. Starting with a thorough discussion of wave motion and its light ramifications, the author later introduces the quantum theory and, finally, considers briefly the problems now being studied by leading workers in optics.

LOKI; THE LIFE OF CHARLES PROTEUS STEINMETZ.

By Jonathan Norton Leonard. 291 pp., illus., ports., 8 x 6 in., cloth. $2.75.

An interesting popular account of Steinmetz's life and his connection with the Central Electric Company, in which his personality, rather than his scientific achievements, is emphasized.

MACHINE DESIGN.

By P. H. Hyland and J. B. Kommers. N. Y., McGraw-Hill Book Co., 1929. 448 pp., illus., diagrs., tables, 9 x 6 in., cloth. $4.00.

Covers the course given by the authors at the University of Wisconsin. While no claim is made for originality of subject matter, the arrangement, treatment and choice of matter are new in certain respects. The fundamental principles are presented with an analysis of only a few applications. Kinematics is incorporated as an integral part of machine design, a plan that obviates, in the opinion of the authors, any need for a separate text on it.

MANUEL PRATIQUE DE SOUDURE AUTOGENE.

By R. Granjon and P. Rosemberg. 2d edition. Paris, Dunod, 1929. 410 pp., illus., 9 x 6 in., paper. 33,70 fr.

This handbook of welding practise has been very popular for years in France and has also appeared in an English translation. Apparatus for autogenous welding, methods, and their application to steel, iron, copper, brass, lead, aluminum, etc., are described in detail. This edition is revised, enlarged, and brought up to date.

MODERN AVIATION ENGINES.

By Major Victor W. Pagé. N. Y., Norman W. Henley Publ. Co., 1929. 2 v., illus., diagrs., tables, 9 x 6 in., cloth. $9.00. 2 v.

Major Pagé has brought together a vast amount of practical information in these two volumes, which are intended chiefly for those occupied with maintenance and repair of aviation engines. The work includes detailed descriptions of practically every engine of any importance, with instructions for their care and repair, and also explains the theoretical principles involved in internal combustion engines. Good diagrams and illustrations are used profusely. A valuable reference book for practical men.

OIL ENGINE POWER PLANT HANDBOOK. 1929.

5th edition. N. Y., National Trade Journals, Inc., 1929. 288 pp., illus., 11 x 8 in., cloth. $5.00.

A collection of practical articles on the operation of Diesel engines; on air filtration, oil purification, cooling towers and other plant accessories; and on the uses and economics of Diesel engines. Contains also brief descriptions and illustrations of the engines actively sold in America.

POPULAR RESEARCH NARRATIVES, v. 3.

Collected by the Engineering Foundation. Baltimore, Williams & Wilkins Co., 1929. 174 pp., ports., 8 x 5 in., cloth. $1.00.

Fifty brief stories of what scientific research has accomplished or is accomplishing, covering a wide variety of topics. Each storyteller is intimately associated with the work that he describes, and tells his story simply and interestingly.

DAS RECHNEN MIT SYMMETRISCHEN KOMPONENTEN.

By Günther Oberdorfer. Lpz. u. Ber., B. G. Teubner, 1929. 74 pp., diagrs., 8 x 5 in., paper. Price not given.

A textbook upon the application of this method of calculation to the problems of electrical engineering. Starting with elementary principles, the method is developed and its application to various problems illustrated, with the object of making the method more widely known among engineers.

TECHNOLOGISCHES HANDBUCH DER ELEKTROTECHNIK UND DER ELEKTROCHEMIE.

By Alfred Schlomann. Berlin, Technische Wörterbucher-Verlag, and V. D. I. Verlag, 1929. 1491 pp., illus., 10 x 7 in., cloth. 41.-r. m.

A concise encyclopedia of electrical engineering which gives a remarkable amount of definite, accurate information in a volume of moderate size. By the use of black-face type for important terms, of numerous sketches, and an unusual typographical arrangement, rapid use has been greatly facilitated, and an elaborate index has been provided also. The book is uniform with the author's well-known six-language dictionary and constitutes a sort of developed commentary to that work.

THEORY AND DESIGN OF ELECTRIC MACHINES.

By F. Creedy. N. Y., Isaac Pitman & Sons, 1929. 349 pp., illus., diagrs., tables, 9 x 6 in., cloth. $9.00.

New possible types of dynamo-electric machines, says the author, are announced almost every month, and it is evident that the possibilities are endless. To assist development he has undertaken this general survey of theoretical possibilities, in which they are classified scientifically and lines along which development offers promise are indicated.

Starting with the theory of the general machine, one limitation after another is introduced and explained critically. Machines are thus classified into six groups, containing all possible types. Attention is then concentrated on cascade sets, multiple polarity machines and variable polarity apparatus, the three groups of which, in the author's opinion, we know least at present.

The final section gives general methods of designing which eliminate guesswork and estimating, and make possible a critical comparison of the possibilities of different types in advance of experiment.

WÄRMEWIRTSCHAFT IM EISENBAHNWESEN.

By Fr. Landsberg. Dresden u. Lpz., Theodor Steinkpoff, 1929. (Wärmelehre und Wärmewirtschaft......v. 7) 207 pp., illus., diagrs., tables, 9 x 6 in., paper. 13.-r. m.

An application of the general principles of fuel economy to the specific problems of railroad operations. Covers all the various uses of fuel in train operation, in shops, and in stations. The organization of the fuel department is considered, as well as technical methods of economy.

Engineering Societies Employment Service

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1216 Engineering Bldg., 205 W. Wacker Drive, Chicago, Ill., A. K. Krauser, Manager.
57 Post St., San Francisco, Calif., N. D. Cook, Manager.

MEN AVAILABLE.—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to EMPLOYMENT SERVICE, 31 WEST 39th Street, New York City, and should be received prior to the 15th day of of the month.

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary: temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

POSITIONS OPEN

GRADUATE ELECTRICAL ENGINEER for publicity work. An attractive and permanent position immediately available. Give full outline of education, experience, and approximate expectations. Location, East. W-13.

ENGINEER, for Utilities Commission; must be college graduate in electrical or mechanical engineer with experience in utility operation or evaluation. Salary $3600-$4000 a year. Apply by letter. Location, South. W-14.

ELECTRICAL ENGINEER, thoroughly familiar with the requirements of the paper mill industry. Must be capable of designing, layout, installation and supervision of entire electrical system, wiring, apparatus, and equipment, all appertaining to construction and operation of modern paper mills. Apply by letter giving full and complete information such as age, technical training, previous experience, present salary, references, etc., location, South. X-9625-OS.

ELECTRICAL ENGINEER, college graduate, 28-38, with practical experience in electrical generation construction, transmission, and maintenance, for industrial concern. Apply by letter giving complete details. Location, Pennsylvania. X-9789.

ELECTRICAL ENGINEER with several years' experience in design of d-c. machines, for manufacturer of electrical machinery. Apply by letter stating age, education, experience, references, and salary expected. Location, Middle West. X-9812-C.

TRANSFORMER ENGINEER, experienced in the design of power transformers. Apply by letter giving age, married or single, experience, salary expected and when available. Location, New Jersey. X-9758.

DESIGNERS, electrical engineers with thorough technical education, and at least four years' commercial experience in synchronous-motor design and application engineering. Permanent employment with chance for advancement according to ability. Apply by letter. Location, Middle West. X-9911-C.

GRADUATE ELECTRICAL ENGINEER, with one or two years' experience in engineering and manufacturing practise with manufacturer of synchronous motors and their control and capacitors. Apply by letter. Location, Middle West. X-9912-C.

GRADUATE ELECTRICAL ENGINEERS for design and test work on accessories for underground power cables having wide range of voltages. One to five years' experience, not necessarily on cable work. Apply by letter. Location, Middle West. X-9960-C.

CABLE ENGINEERS for large public utility. Work is in tests, research specifications, and allied problems on underground power cables. Few years engineering experience, but cable experience not required. Apply by letter. Location, Middle West. X-9959-C.

ELECTRICAL ENGINEER, graduate, young, to enter sales department in connection with sale of miscellaneous heavy duty types of storage batteries; for instance, oil switch, emergency lighting and motive power installations. Opportunity. Apply by letter. Location, Maryland. X-7776.

ENGINEER, young, speaking at least one foreign language, for installation and maintenance of electro-medical apparatus. After approximately 18 months satisfactory work in the United States, may be sent abroad on sales and engineer ing assignments. Apply by letter giving complete details, references, etc. Headquarters, Chicago. X-7388-C.

RECENT GRADUATE, electrical engineer willing to locate in eastern territory near Philadelphia and to enter traveling sales work, handling a-c. motors and fans. Must have clean cut personality. Apply by letter. Headquarters, Middle West. X-3172-C.

ENGINEER, with telegraph and telephone experience. Must be qualified to handle engineering problems in telephone transmission, inductive interference, and telegraph and telephone installations. Apply by letter. Salary $250 a month. X-9973.

MEN AVAILABLE

ELECTRICAL ENGINEER, 37, married, graduated from Germany. Six years' high-voltage sub power station, transmission line layout, design, material, with hydroelectric power plants in Europe. Six years of public utility, drafting, design, construction of sub and power stations in New York City. Available at short notice. C-2408

ELECTRICAL ENGINEER, wide experience in construction, operation, maintenance, generating, transmission at 100,000 volts, underground transmission, 6600 and 22,000 volts, outdoor and indoor substations, mill installations. Has had sales and managing experience in Latin America and India. Speaks English, Spanish, German, French and Hindustani. Location, immaterial. Now employed. C-1222.

ELECTRICAL ENGINEER, age 29, five years' varied experience, test floor, application, design, construction and maintenance. Now in charge of electrical department for mining company. Desires position as assistant plant engineer or assistant electrical engineer with large industrial plant. Good personality and very well recommended. B-9001.

ELECTRICAL ENGINEER, having 10 years' practical experience in transmission distribution and testing, is desirous of a connection with progressive concern. Speaks French, German, and Russian. Location, Europe. B-7412.

HYDROELECTRICAL ENGINEERING GRADUATE of Washington State, (1928,) single, 26, eight months' experience in installation of switch-yard control apparatus and distribution, also previous construction experience. Desires work applying electrical engineering. Principals, anywhere. C-6586.

GRADUATE ELECTRICAL ENGINEER, EXECUTIVE, now employed, 33, married, 10 years' experience, design supervision of construction, generating and railway converter substations. Invites correspondence from public utilities where opportunity for advancement. Member N. E. L. A. B-6600.

ELECTRICAL ENGINEER, 38, college graduate, 12 years' experience in power-plant and substation design, construction, and maintenance, three years with consulting engineers specializing in public utilities problems; desires to connect with public utility company as assistant to manager or operating engineer. Location immaterial. Now employed. Opportunities for advancement of primary importance. C-3425.

ENGINEER EXECUTIVE, experienced in industrial relations and managerial problems. Diversified training includes design, production, economic studies, statistical analysis and personnel. Post graduate work in business administration. Permanent connection with industrial concern or consulting engineer desired. Available on month's notice. C-6609.

ELECTRICAL ENGINEER, 23, single, 1927 graduate, varied experience in test department of large power and light company and in engineering department of small electrical manufacturing concern, desires position in engineering department of public utility. Now employed. Location preferred, East. C-6583.

SUPERVISING AND ESTIMATING ENGINEER, 25 years' experience in commercial and industrial power installations. Has had wide experience in all classes of buildings construction work, from both a practical and theoretical standpoint including underground and substation installations. Capable executive and engineer. Location, New York if possible. C-1140.

ELECTRICAL ENGINEER, B. S. and M. S. in electrical engineering, M. I. T General Elec-

tric Test and central station department training course with large utility, desires position with public utility, or firm of consulting engineers. Available about January 15. Location, immaterial. C-2753.

GRADUATE ELECTRICAL ENGINEER, 32, 10 years' experience, expert light, heat, power, plans specifications, engineering, correspondence, for theaters, hotels, skyscraper offices, apartments, public buildings, etc. Thorough experience with architects, contractors, and consulting engineers. Desires connection anywhere as designing or estimating engineer. Capable, neat, thorough, conscientious, possesses personality, initiative, a sense of values. B-4217.

ENGINEER, 31, single, with exceptional technical training, desires permanent position. Diversified engineering experience and specialized Diesel-electric development, testing or sales and service work preferred. Work conducive to individual development allowing advancement to executive position of primary importance. C-6493.

ELECTRICAL ENGINEER, 28, single, B. S., 1929, graduated with high honors, desires connection with manufacturer of electrical machinery or utility company. Preferably production, management, or design. Opportunity for advancement considered most important. Two years' test floor experience. Location, Eastern States or abroad. Excellent knowledge of Russian. Available on short notice. C-6526.

TECHNICAL GRADUATE, 31, nine years electrical contracting, layout supervision estimating on theater electrical systems, public address system, hotel and office building power and light systems, street lighting. Long experience selling builders and executives. Knowledge of economics and finance, desires position where past experience and executive ability can be utilized. C-6613.

ELECTRICAL ENGINEER, 28, married, desires permanent connection. Four years with large rapid transit company maintenance, powerhouse, substation operation, high-voltage testing, calibration of potential and current transformers. One year cable manufacturing design, construction, estimating compute electrical characteristics, development work on cable and joints for 132-kv. underground cable. Location immaterial. C-4420.

ELECTRICAL-MECHANICAL ENGINEER, 12 years' experience in testing, design, and development of d-c. motors and generators of the traction type. Now employed by electrical manufacturer as motor design engineer. Desires similar position with company offering opportunity for advancement in design and manufacture. Age, 38, college graduate, married. B-3152.

ELECTRICAL ENGINEER, 29, 1923 graduate, married 1 1/2 years Westinghouse test, 1 1/2 years over-head distribution design, 3 1/2 years transmission line and substation extension planning, cost, estimating, calculating, budget, tax, and general public utility engineering office work; desires position of responsibility in distribution or transmission engineering in East or South. C-3694.

RESEARCH ELECTRICAL ENGINEER, 28, E. E. and M. E. graduate from European Technical College, naturalized, married, 7 years' experience in design of automatic-control apparatus, X-ray equipment, photoelectric measuring apparatus. Capable of original and independent work. Desires responsible position in research department of eastern concern. References. Available on short notice. B-6782.

MEMBERSHIP—Applications, Elections, Transfers, Etc.

RECOMMENDED FOR TRANSFER

The Board of Examiners, at its meeting of November 13, 1929, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grade of Fellow

ALGER, PHILIP L., Assistant to the Vice-President in Charge of Design Engg., General Electric Company, Schenectady, N. Y.

To Grade of Member

ACHARD, FRANCIS H., Instructor in Charge, Educational Bureau, Brooklyn Edison Co., Brooklyn, N. Y.

BEILER, ALBERT H., Electrical Engineer, American Gas & Elec. Co., New York, N. Y.

BROWNE, WILLIAM HAND, Jr., Professor of Electrical Engineering, North Carolina State College, Raleigh, N. C.

CASTRO, CARLOS, Transmission Engineer, Columbia Engg. & Mgt. Corp., Cincinnati, Ohio.

DRESSNER, VICTOR D., Engineer in Transmission & Distribution Dept., New York Edison Co., New York, N. Y.

Du BOIS, WARREN L., Electrical Designer, Department of City Transit, Philadelphia, Pa.

FLACOUS, GEORGE W., Electrical Engineer, Electrical Research Products Inc., New York, N. Y.

HARRISON, WILLIAM H., Plant Engineer, American Tel. & Tel. Co., New York, N. Y.

HOLLISTER, FRANCIS H., Electrical Engineer, Sargent & Lundy, Chicago, Illinois.

IRVINE, C. NES, Electrical Engineer, Gustav Hirsch Organization, Columbus, Ohio.

KEELER, WILLIAM H. E., Assistant Engineer, New York Telephone Co., New York, N. Y.

MITCHELL, OSBORNE S., Editor, *Electrical News and Engineering*, Toronto, Ont., Canada.

PIATT, WILLIAM M., Professional and Consulting Engineer, Durham, N. C.

SERVICE, JERRY H., Head of Departments of Physics and Mathematics, Henderson-Brown College, Arkadelphia, Arkansas.

TENNEY, HARRY W., Section Engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before December 31, 1929.

Amitay, A., New Jersey Power Co., Asbury Park, N. J
Babcock, C. W., General Electric Co., Schenectady, N. Y.
Baier, H., Otis Elevator Co., New York, N. Y.
Barber, H., New England Power Construction Co., Boston, Mass.
Barrett, T. L., T. M. E. R. & L. Co., Milwaukee, Wis.
Barry, L. A., Jr., 262 Elmwood Ave., Maplewood, N. J.
Barth, C. A., (Member), So. Bell Tel. & Tel. Co., Atlanta, Ga.
Barton, J. P., Westinghouse Elec. & Mfg. Co., Chicopee Falls, Mass.
Beck, D. B., Metropolitan Edison Co., Reading, Pa.
Becker, A., Diehl Mfg. Co., Elizabethport, N. J.
Beerman, M. R., Alabama Power Co., Birmingham, Ala.
Bellows, K. F., New York Edison Co., New York, N. Y.
Berry, P. M., W. N. Matthews Corp., St. Louis, Mo.
Black, R. R., General Electric Co., Fort Wayne, Ind.
Brandstoettner, W. H., American Tel. & Tel. Co., New York, N. Y.
Brumbaugh, K. D., Dingle-Clark Co., Cleveland, Ohio
Brundrett, G. T., Hubbard & Co., Dallas, Tex.
Caporale, P., Radio-Victor Corp. of America, Philadelphia, Pa.
Capron, R. B., Utica Gas & Electric Co., Utica, N. Y.
Carver, L. A., Paramount Fire Alarm Engineering Co., Cleveland, Ohio
Casciato, D., Electrical Research Products, Inc., Chicago, Ill.
Chubbuck, E. E., (Member), Phoenix Utility Co., Allentown, Pa.
Claridge, R. E., Northern Electric Co., Toronto, Ont., Can.
Clark, E. N., Northern States Power Co., Minneapolis, Minn.
Clements, L. J., Box No. 647, Redwood City, Calif. (Applicant for re-election.)
Coe, R. J., Connecticut Power Development Co., East Barnet, Vt.
Cohn, A. G., Kansas City Power & Light Co., Kansas City, Mo.
Culver, D. N., Bell Telephone Co. of Canada, Montreal, Que., Can.
Dansboe, H. H., Atlantic Oil Producing Co., Dallas, Tex.
de Carvajal, C. A. R., 229 East 26th St., New York, N. Y.
Deck, A. R., Metropolitan Edison Co., Easton, Pa.
De Leau, L. H., Brooklyn Edison Co., Brooklyn, N. Y.
Doty, P. J., General Electric Co., Schenectady, N. Y.
Dutton, A. G., Pennsylvania Power & Light Co., Allentown, Pa.
Eddlestone, J. E., N. Y. & Queens Elec. Lt. & Pr. Co., Flushing, (L. I.), N. Y.
Ehst, M. R., W. S. Barstow & Co., Inc., Reading, Pa.
Elge, E. A., General Electric Co., Pittsfield, Mass.
Emrick, A. B., Wagner Electric Corp., Dallas, Tex. (Applicant for re-election.)
Exner, D. W., Westginhouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Finney, C. F., Jersey Bell Tel. Co., Newark, N. J.
Frambes, R. T., W. S. Barstow & Co., Inc., Reading, Pa.
Freundt, G. L., American Can Co., Maywood, Ill.
Frey, R. C., Pacific Telephone & Telegraph Co., San Francisco, Cal.
Gear, R. B., Commonwealth Edison Co., Chicago, Ill.
Geiser, W. D., Philadelphia Electric Co., Philadelphia, Pa.
George, H. C., Detroit Edison Co., Detroit, Mich.
Goeller, C. P., General Electric Co., Lynn, Mass.
Gough, J. H., Westinghouse Elec. & Mfg. Co., Chicopee Falls, Mass.
Grabow, H., Pacific Gas & Electric Co., San Francisco, Calif.
Gritte, J. M., Staten Island Edison Corp., Livingston, S. I., N. Y.
Hartig, C. F., New York Edison Co., New York, N. Y.
Hartig, O., (Member), Eagle Electric Mfg. Co. Brooklyn, N. Y.
Hartman, E. R., Firestone Tire & Rubber Co., Akron, Ohio

Hauck, H. C., Western Electric Co., Inc., Newark, N. J.
Herbert, L. P., Penn-Ohio Power & Light Co., Youngstown, Ohio
Hertz, H. F., Philadelphia Electric Co., Philadelphia, Pa.
Hicks, J. M., Century Electric Co., Philadelphia, Pa.
Holland, J. T., Duke Power Co., Charlotte, N. C.
Holman, W. J., Yale University, New Haven, Conn.
Hoppe, W. H., General Railway Signal Co., Rochester, N. Y.
Houston, C. A., Humble Pipe Line Co., Houston, Tex.
Howard, A. W., General Electric Co., Fort Wayne, Ind.
Hunter, J. A., Pennsylvania Power & Light Co., Danville, Pa.
Hurley, E. P., Bright & Co., Reading, Pa.
Innis, H. H., General Electric Co., Schenectady, N. Y.
Jarvis, H. O., City of Baltimore, Dept. of Public Works, Baltimore, Md.
Johanson, A. N., The Gamewell Co., San Francisco, Calif.
Johnson, M. L., Kansas University, Bendena, Kans.
Johnson, R. E., Lake Shore Power Co., Wauseon, Ohio
Jones, C. W., New England Power Construction Co., Boston, Mass.
Jordan, H., Ontario Paper Co., Ltd., Outardes Falls, Que., Can.
Kirkland, J. F., New York Central Railroad Co., New York, N. Y.
Kleindienst, J. G., Delano Coal Co., Inc., New York, N. Y.
Knight, E. B., Saskatchewan Govt. Telephones, Regina, Sask., Can.
Korsznick, J., General Electric Co., Pittsfield, Mass.
Langer, F. C., Alcazar Hotel, San Francisco, Calif.
Leftwich, M. F., Duke Power Co., Charlotte, No. Car.
Lewis, R. C., So. New England Tel. Co., New Haven, Conn.
Lindstrom, H. L., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Lowe, H. L., Louisville Gas & Electric Co., Louisville, Ky.
Luttropp, A. L., Allis-Chalmers Mfg. Co., Pittsburgh, Pa.
MacDonald, H. C., Western Union Telegraph Co., New York, N. Y.
Miller, W. R., Needles Gas & Electric Co., Needles, Calif.
Mitchell, G. T., General Electric Co., Schenectady, N. Y.
Murphy, N. F., Harold E. Trent Co., Philadelphia, Pa.
Nebbia, A. M., Public Service Electric & Gas Co., of N. J., Hackensack, N. J.
Neri, J. M., 928 Washington St., Hoboken, N. J.
Nichol, A. J., Board of Transportation, New York, N. Y.
Noble, W. H., Penna. Pump & Compressor Co., Easton, Pa.
Nowack, D. C., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Oathout, V., Indiana Bell Tel. Co., Indianapolis, Ind.
O'Brien, L. P., Byllesby Engineering & Management Corp., Chicago, Ill.
Olmstead, L. M., Worcester Polytechnic Institute, Worcester, Mass.
Oser, W. K., Bell Telephone Laboratories, Inc., New York, N. Y.
Pastoret, J. E., Reading Co., Philadelphia, Pa.
Pearson, R. H., Westinghouse Elec. & Mfg. Co., Houston, Tex.
Peters, E. B., Pennsylvania Power & Light Co., Allentown, Pa.
Phillips, J. H., Jr., 5510 Baum Blvd., Pittsburgh, Pa.
Pierson, W. D., Erie Malleable Iron Co., New York, N. Y.
Powell, W. M., Rome Wire Co., New York, N. Y.
Ratajczak, F. X., W. S. Barstow & Co., Reading, Pa.
Rehder, E. G., New York Telephone Co., New York, N. Y.
Reibner, O. E., Electric Bond & Share Co., New York, N. Y.
Rheins, J. J., Purdue University, West Lafayette, Ind.
Rhodes, D., Bell Telephone Co. of Canada, Montreal, Que., Can.
Roush, W. L., Westinghouse Elec. & Mfg. Co., Houston, Tex.
Sahkovich, R. J. K., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Schattle, R. B., Syracuse Washing Machine Corp., Syracuse, N. Y.
Schmidt, M. L., General Electric Co., Fort Wayne, Ind.
Schrock, J. E., General Electric Co., Erie, Pa.
Schwietering, P. J., Cudahy Brothers Co., Cudahy, Wis.
Searles, N. F., General Electric Co., Fort Wayne, Ind.
Secor, C. K., Brooklyn Polytechnic Institute, Brooklyn, N. Y.
Sergeant, R. E., Metropolitan Edison Co., Reading, Pa.
Setterstrom, R. C., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Silverman, J., Brooklyn Edison Co., Brooklyn, N. Y.
Snyder, W. R., J. G. White Management Corp., Reading, Pa.
Solomon, M. C., Central Illinois Light Co., Peoria, Ill.
Sticher, J., Detroit Edison Co., Detroit, Mich.
Stiegelmeier, W. E., Chicago Rapid Transit Co., Chicago, Ill.
Street, M. G., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Taylor, T. A., American Tel. & Tel. Co., New York, N. Y.
Thomas, H. E., R. C. A. Communications, Inc., Marshall, Calif.
Trenary, H. I., Victor X-Ray Corp., Chicago, Ill.
Underwood, R. J., New England Power Association, Providence, R. I.
Verrall, V. E., General Electric Co., Fort Wayne, Ind.
Weber, A. N., Lynn Gas & Electric Co., Lynn, Mass.
Whelchel, C. C., Jr., (Member), General Electric Co, Schenectady, N. Y.
White, C. E., General Electric Co., Fort Wayne, Ind.
White, J. E., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Whiting, J. G., (Member), Greene Engineers, Inc., Charlotte, N. C.
Wilkie, H., Naval Research Laboratory, Anacostia, D. C.
Williams, T. M., American Tel. & Tel. Co., Pittsburgh, Pa.
Young, C. A., Northwestern Electric Co., Portland, Ore. (Applicant for re-election.)
Total 134

Foreign

Adams, A. L., (Member), South Porto Rico Sugar Co., Ensenada, Porto Rico
Green, J. F., The Macintosh Cable Co., Ltd., Derby, Eng.
Heinlein, K., Heinlein & Cia., Buenos Aires, Argentina, So. America
Lamy, R., Societe de la Mailleraye, Paris, France
Oldfield, V. P., Gowerdene Hotel, London, W. C. 1, Eng.
Picard, A., Compania Standard Electric, Buenos Aires, Argentina, So. America
Rudenberg, R., (Member), Siemens-Schuckertwerke A. G., Verwaltungsgebaude, Berlin-Siemensstadt, Germany
Taguchi, O., Asia Aluminum Co., Tokyo, Japan
Venkatesan, A., T. T. D. Electric Construction, Tirupathi, Madras Presidency, India
Venkateswaran, A. S., M. S. M. Ry., Triplicane, Madras, India
Total 10

STUDENTS ENROLLED

Abbott, W. Irving, University of New Mexico
Adam, Ian M., University of British Columbia
Adams, Norman H., University of California
Adams, William C., University of Illinois
Adcock, Maldan V., Texas A. & M. College
Aldrich, Howard J., Northeastern University
Alexander, Samuel N., University of Oklahoma
Allan, Francis S., State College of Washington
Allen, S. R., State College of Washington
Allen, Stanley L., Northeastern University
Altland, Frederick H., Lehigh University
Anderson, Grant S., State University of New Mexico
Anderson, John E., Calif. Inst. of Tech.
Anderson, McRoy A., South Dakota Stat School of Mines
Andresen, Warren, University of California
Andrews, Leo R., Virginia Military Institute
Appl, Theodore, Kansas State Agri. College
Archer, Samuel W., University of Illinois
Arlio, Dominic C., Northeastern University
Armstead, James G., Rensselaer Polytechnic Inst.
Armstrong, William M., Stanford University
Arvidson, Ernest R., University of Iowa
Arvidson, Paul G., University of Iowa
Ashley, Hilas C., University of California
Ashton, Chester H., Bucknell University
Asmann, James W., University of Cincinnati
Atwood, Albert W., Jr., Calif. Inst. of Tech.
Ayers, Jack W., University of Illinois
Baer, Oscar W., Colorado State Agri. College
Bailey, Charles F., University of Kentucky
Bailey, James G., University of Minnesota
Baker, Paul H., Rose Polytechnic Institute
Baker, Robert F., Cornell University
Balkow, Ernest C., University of Idaho
Ballinger, Mark H., Purdue University
Balzer, Harvey W., University of Missouri
Banca, M. C., University of Illinois
Bangerter, Harry G., State Univ. of New Mexico
Banks, Carl W., Lehigh University
Banks, Dwight H., Kansas State Agri. College
Baptist, Noel A., Rose Polytechnic Institute
Barksdale, Warren F., Mississippi A. & M. Col.
Barlett, Theo. A., Ohio State University
Barnes, George C., West Virginia University
Barnwell, William M., Clemson Agricultural Col.
Barrett, Josiah S., Mass. Inst. of Technology
Baxter, Herbert M., Georgia School of Tech.
Beach, Ralph G., University of California
Beard, W. G., Lehigh University
Bell, Richard A., Ohio State University
Belsher, Gregory T., University of Idaho
Benning, Harvey H., Jr., Cornell University
Benson, John C., University of Kentucky
Bergstrom, Roland F., University of California
Berry, Leaman S., University of Maine
Billman, Leroy S., Lehigh University
Black, Addison F., Jr., Virginia Military Institute
Black, Harry C., University of Kentucky
Black, Raymond G., University of Illinois
Blackwood, Herbert B., Virginia Military Inst.
Blair, Royer R., Rose Polytechnic Institute
Bloss, Theodore, University of Oklahoma
Blum, Frederick A., University of Cincinnati
Blythe, Joseph W., Iowa State College
Bolliger, Theodore C., University of Wisconsin
Bollman, V. L., University of Nebraska
Bolton, Stanley W., Cornell University
Bong, Tom, University of Washington
Boltz, Jay Harold, Lehigh University
Bondley, Ralph J., Ohio Northern University
Bovey, Donald E., Iowa State College
Bowen, H. L., Georgia School of Technology
Bowes, Theodore L., University of Illinois
Bowker, Marshall E., Univ. of New Hampshire
Boyles, Ronald M., University of Washington
Bozick, John F., Kansas State Agricultural Col.

Brainard, William E., Cornell University
Branaman, William H., University of Kentucky
Branham, Elmer J., Kansas State Agri. College
Branson, Orland D., Iowa State College
Brewster, Todd W., Municipal Univ. of Akron
Britt, Albert S., Virginia Military Institute
Brodnax, Joe T., Virginia Military Institute
Brower, Ralph B., University of California
Brown, Charles T., Lafayette College
Brown, Howard F., University of Kentucky
Brown, Marion W., Purdue University
Brown, Stuart C., University of Illinois
Brown, Tomme M., University of Oklahoma
Buch, Phil, Purdue University
Buchanan, Royal S., University of Illinois
Bull, James T., Cornell University
Burbank, John H., Northeastern University
Burge, Donald S., Purdue University
Burgess, Everett H., Rensselaer Polytechnic Inst.
Burnham, Lyle M., University of Texas
Butler, Roland D., University of Maine
Byrnes, Leon M., Clarkson College of Technology
Caldera, Felix C., University of California
Caldwell, Chester W., Purdue University
Caldwell, F. R., Cornell University
Caldwell, John H., Jr., Cornell University
Calkins, Delos S., Cornell University
Camp, Byron L., Pennsylvania State College
Campbell, Doyne L., University of Oklahoma
Campbell, Guy C., University of Utah
Carbray F. J., McGill University
Carland, James F., Iowa State College
Carlen, Jans J., University of New Hampshire
Carlson, Edward J., University of California
Carlson, Reuben J., University of Washington
Carlstad, Alvin, State College of Washington
Carter, Ernest D., University of Missouri
Caughman, Martin W., Clemson Agricultural Col
Cawby, Elmer L., University of Kentucky
Chaffee, F. Dudley, Worcester Polytechnic Inst.
Chamberlain, Glenn J., Calif. Inst. of Tech.
Chang, Kung-Huan, Cornell University
Chanon, Henry J., Ohio State University
Chapman, John L., Clemson Agricultural College.
Charbonneau, Allan P., University of Kentucky
Cherry, John T., North Carolina State College
Church, Robert A., University of Oklahoma
Clark, Eldon M., So. Dak. State School of Mines
Clark, George H., Cornell University
Clark, John R., Northeastern University
Clarke, George J., University of Illinois
Cloran, Charles R., Northeastern University
Cocanower, G. M., Purdue University
Cochran, William L., Alabama Polytechnic Inst.
Cohenour, Howard H., University of Illinois
Colot, Robert, Rutgers College
Colvin, Charles E., Jr., University of Kentucky
Comerford, Thomas G., Northeastern University
Comings, Mary B., Stanford University
Conrath, Robert E., Cornell University
Constantine, Jerry Jay, University of Kentucky
Conway, Clarence E., University of Idaho
Cooper, Robert D., So. Dak. State School of Mines
Cooper, Robert E., Jr., University of California
Cooper, Winfield T., University of Illinois
Corbin, Joseph E., Pennsylvania State College
Corley, John D., Ohio State University
Corp. James H., Rose Polytechnic Institute
Corwin, Newell J., Rensselaer Polytechnic Inst.
Coryell, Walter R., Jr., Washington University
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NEW CATALOGUES AND OTHER PUBLICATIONS

Mailed to interested readers by issuing companies

Mercury Arc Rectifiers.—Bulletin GEA-1151, 20 pp. Describes mercury arc rectifiers for railway service. General Electric Company, Schenectady, N. Y.

Chain Grate Stoker.—Catalog GND-2, 28 pp. Describes the Green Natural Draft Chain Grate Stoker, applicable to boilers of all types where the load and operating conditions are such that a natural draft chain grate stoker is suitable. It is stated that this is one of the pioneer stokers of its type and is installed under boilers of more than 1,200,000 rated boiler horsepower. Combustion Engineering Corporation, 200 Madison Avenue, New York.

Motor Maintenance Equipment.—Catalog B-829, 58 pp. Describes motor maintenance equipment and electrical specialties. The equipment includes commutator resurfacers, grinders, mica undercutters, slotting files, blowers, etc. The catalog contains instructions for the operation of d-c. generators, a chapter which treats in detail some fifty commutator troubles and remedies; definitions of electrical terms; and tables on the current-carrying capacity of solid and stranded wires, as well as tables on fusing, wiring and full load current data. Ideal Commutator Dresser Co., Sycamore, Ill.

Electrical Distribution Systems.—Bulletin 31-C-62, 16 pp. Describes Bull Dog "Bus-DUCT" and "Trolley-DUCT." The latter is a flexible system of electrical control for portable electrical tools as used on moving assembly lines in automobile and other mass production plants. Bus-DUCT is a bus bar system of electrical power distribution for industrial plants employing mass production methods, where frequent and repeated changes in location of machines, motors and sometimes whole departments are desired on short notice. It displaces, to some extent, the older method of distribution by conduit, wires and power panels. Bull Dog Electric Products Co., 7610 Jos. Campau Avenue, Detroit, Mich.

NOTES OF THE INDUSTRY

The Wagner Electric Corporation, St. Louis, has appointed D. O. Reardon as representative for part of Iowa, with headquarters in Des Moines, Iowa.

The Ohio Brass Company, Mansfield, Ohio, announces that its Boston office in charge of Harvey H. Hoxie, has been removed from its former location in the Little Building to Room 1001, Statler Building, 20 Providence Street.

The Kuhlman Electric Company, Bay City, Mich., manufacturers of power, distribution and street lighting transformers, announces the appointment of Frank C. Fassett, 15 East Jackson Street, Phoenix, Arizona, as its representative in that territory.

The Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has appointed T. B. Wood's Sons Company, Chambersburg, Pa., as special distributors of Texrope drives. A large stock of Texrope drives and Texrope belts will be carried so as to render prompt and efficient service.

The Inca Manufacturing Corporation has announced the construction of a large addition to the new factory at Fort Wayne, Ind., trebling the capacity of the present plant. The structure will be completed shortly after the first of the year. The plant, which was founded by George A. Jacobs and associates, manufactures copper wire products for the radio, electrical and automotive industries.

Paul Stauffer has been appointed eastern manager of the company with headquarters at Newark, N. J., and R. A. Connor has joined the sales and engineering staff at Fort Wayne.

Westinghouse Builds Large Synchronous Converters.—The Roessler and Hasslacher Chemical Company, of Niagara Falls, has recently ordered two 16,000 ampere, 340 volt d-c. synchronous converters from the Westinghouse Electric & Manufacturing Company. These machines will have the largest current rating of any converting equipment in electrolytic service, increasing by 60% the current rating of any previously installed converter used for this purpose. Switching equipment for the converters and two 5800 k-va., 3-phase transformers with tap changers were also included in the order.

New Small Motor Starter.—A new counter E. M. F. type automatic starter has been developed by Cutler-Hammer, Inc., 163 12th St., Milwaukee, Wis. This new, small motor starter incorporates a number of new and important features such as: small size, reduced voltage starting, thermal overload protection, low voltage protection and renewable silver contacts. It is rated up to 2 hp., 115 or 230 volts. The contactors are designed especially for direct current service and the renewable silver contacts insure long life. Each starter is supplied with a separate pushbutton master switch providing three-wire remote control. Two wire control can be furnished, if desired.

Electric Ships for the Pacific.—Two vessels over 600 feet long, with turbine-electric propulsion and otherwise completely electrically equipped are to be constructed by the Newport News Shipbuilding and Dry Dock Company for the Dollar Steamship Line. The vessels will be sister ships of twin-screw design and built for a speed of 20 knots. The first one to be constructed will be completely electrified by the General Electric Company. It will have accommodations for 450 passengers and a crew of more than 300. The power plant on the first boat will consist of two 11,000 shaft-horsepower turbines running at 2500 r. p. m. and driving two alternating-current generators each having a continuous rating of 10,100 kilowatts, 3-phase, 4800 volts. These main propulsion generators will supply electricity for driving two 13,250 horsepower, synchronous-induction motors, each connected to one of the two propellor shafts which will turn at the rate of 133 r. p. m. Excitation and power for operating auxiliaries and lighting will be furnished by four 500-kilowatt, 240-volt, compound-wound, direct-current turbine generators of the geared type. Electrification of the auxiliaries will be practically complete, even to the extent of the general use of electric heat.

Soviet Russia Employs American Engineers.—Several score engineers and foremen have recently been engaged to work in Soviet industrial and agricultural organizations, according to announcement of the Amtorg Trading Corporation. The American engineers who have either left or will leave shortly for work in the Soviet Union, include experts in the metal industries, construction, irrigation, mining, etc. While a large number of technical assistance contracts, providing for sending about 200 American engineers to the Soviet Union, have been concluded within the past year with American firms, no contracts with individual engineers were made until recently. In view of the announced policy of the Soviet government to employ foreign technical talent to a greater degree, it is expected that a number of additional American engineers will be engaged for work in industrial and agricultural enterprises of the U. S. S. R. Among the individual American engineers who have been retained by Soviet organizations are seven hydraulic engineers headed by Arthur P. Davis, formerly chief of the United States Reclamation Service, who will supervise the irrigation projects in Central Asia and Transcaucasia. A number of other Soviet industrial organizations have announced the intention of inviting foreign engineers, foremen and supervisors for work in their enterprises. The employment of American engineers and other technical personnel is done through the Amtorg Trading Corporation, 261 Fifth Avenue, New York, representatives in this country of a number of the principal Soviet industrial enterprises.